

# THE LANCET

## **Supplementary appendix**

This appendix formed part of the original submission and has been peer reviewed.  
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Supplement to: Canfell K, Kim JJ, Brisson M, et al. Mortality impact of achieving WHO cervical cancer elimination targets: a comparative modelling analysis in 78 low-income and lower-middle-income countries. *Lancet* 2020; published online Jan30. [http://dx.doi.org/10.1016/S0140-6736\(20\)30157-4](http://dx.doi.org/10.1016/S0140-6736(20)30157-4).

# Appendix for the manuscript: Mortality impact of achieving WHO cervical cancer elimination targets: a comparative modelling analysis in 78 low-income and lower-middle-income countries

## Contents

Part 1. Additional results .....	3
Section 1. Calibration results .....	3
Figure AR1. Calibration results for the three CCEMC models, showing model predictions for status quo vs. the Globocan 2018 age-specific cervical cancer incidence and mortality rates.....	4
Section 2. Detailed results for projected cervical cancer rates over time .....	8
Table AR1. Reduction in cervical cancer mortality over time across all 78 LMIC countries.....	8
Section 3. Age-specific cervical cancer incidence and mortality rate results for each model .....	11
Figure AR2. ‘Snapshots’ of age-specific cervical cancer incidence and mortality rates across (a) all 78 LMIC countries; (b) regional results (i) East Asia & Pacific, (ii) Europe & Central Asia, (iii) Latin America & Caribbean, (iv) Middle East & North Africa, (v) South Asia, (vi) Sub-Saharan Africa. ....	12
Section 4. Deaths averted by region for the triple-intervention strategy S3.....	26
Table AR2. Cumulative cervical cancer deaths averted (millions) for the triple-intervention scenario S3 across all-78 LMIC countries, and by region, over three time periods. ....	26
Section 5. Country-level results .....	27
Table AR3. Country-level results. ....	27
Section 6. Explanatory and sensitivity analysis results .....	33
Figure AR3. Explanatory analyses of the combination of different interventions over time: Age-standardised mortality rates across all 78 LMICs .....	34
Figure AR4. Sensitivity analysis showing the impact of using different standard populations on the age-standardised rate of cervical cancer mortality in 2120: All-78 LMICs.....	41
Figure AR5. Sensitivity analysis showing the impact of using the low fertility variant and high fertility variant population projections on the predictions of cumulative cancer deaths averted to 2120 (over the period 2020-2120): All-78 LMICs.....	43
Part 2. Technical Appendix .....	44
Section 1. Description of the 78 low- and lower-middle-income countries included in the analysis .....	44
Table A1. Countries by geographic regions.....	44
Table A2. Countries by income groups.....	45
Section 2. Population standardisation for estimates of cervical cancer elimination .....	46
Table A3. Population structure for age-and-time standardisation rates for cervical cancer incidence and mortality.....	47
Section 3. Population projections beyond 2100 .....	48
Figure A1. Population predictions by income level and region .....	49
Section 4. Detailed model descriptions for the CCEMC models .....	50
Policy1-Cervix (Cancer Council NSW, Australia).....	50
Figure A2. Model structure - Policy1-Cervix .....	52
Harvard model (Harvard University, USA) .....	53
Figure A3. Model structure – Harvard model.....	54
HPV-ADVISE: Agent-based Dynamic model for Vaccination & Screening Evaluation (Laval University, Canada) .....	55
Figure A4. Model structure - HPV-ADVISE.....	56

Section 5. Detailed description of modelled scenarios (including <i>status quo</i> , core, supplementary, and explanatory scenarios).....	57
Table A4. Summary of status quo, core and supplementary scenarios considered.....	59
Table A5. Detailed description of status quo, core, supplementary and exploratory scenarios considered .	60
Section 6. Detailed description of initial (pre-calibration) model assumptions for cancer treatment access, stage distribution, and survival.....	63
Table A6. Assumed initial status quo country-specific stage distributions, survival rates, and treatment access rates.....	64
Table A7. Assumed stage-specific survival after scale-up of treatment access to 90%, all countries .....	71
Figure A5. Schematic showing treatment modelling approach for S0 and S3.....	72
Section 7. HPV-FRAME reporting standard.....	74
Table A9. HPV-FRAME reporting standard checklist .....	74
Appendix references .....	77

## **Part 1. Additional results**

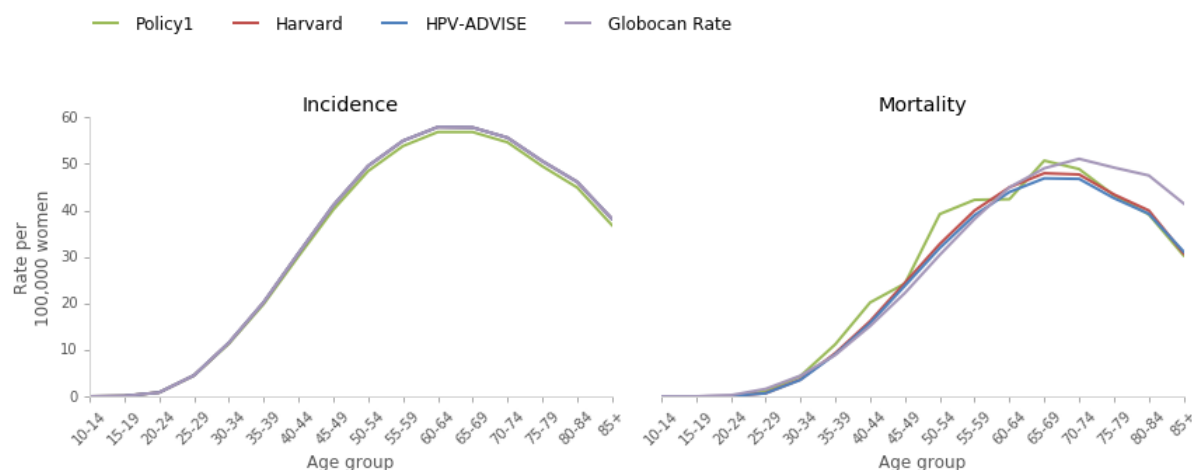
### **Section 1. Calibration results**

GLOBOCAN 2018 comprises the most comprehensive estimates of current age-specific cervical cancer incidence and mortality; the estimates are based on IARC-certified cancer registry information where available in a country, or on a series of estimation methods if verified registry data are not available. Each group incorporated initial stage-specific 5- and 10- year survival assumptions for a country, and the models were then calibrated to country- and age-specific mortality rates from GLOBOCAN 2018 by incorporating a quality factor into the final estimated country- and stage-specific survival assumptions. The quality factor encompasses limitations in the available data on staging, treatment access and survival, uncertainties in actual delivery of treatment, and also notionally encompasses variations in treatment delivery from established protocols and recommendations, equipment and infrastructure maintenance and logistics, and treatment abandonment due to financial stress or other reasons. The final calibrated results for each model for both incidence and mortality are shown here, summarised across all 78 LMICs and at the regional level. Results of the model calibration were comparable for all three models and generally demonstrated good fit with GLOBOCAN 2018.

**Figure AR1. Calibration results for the three CCEMC models, showing model predictions for status quo vs. the Globocan 2018 age-specific cervical cancer incidence and mortality rates.**

Note that calibration was done at a country level but results across all 78 LMICs are shown. Estimates weighted to all 78 LMICs were obtained by using a population-weighted average of all countries included in this analysis for both incidence and mortality, using population projections for the year 2020.

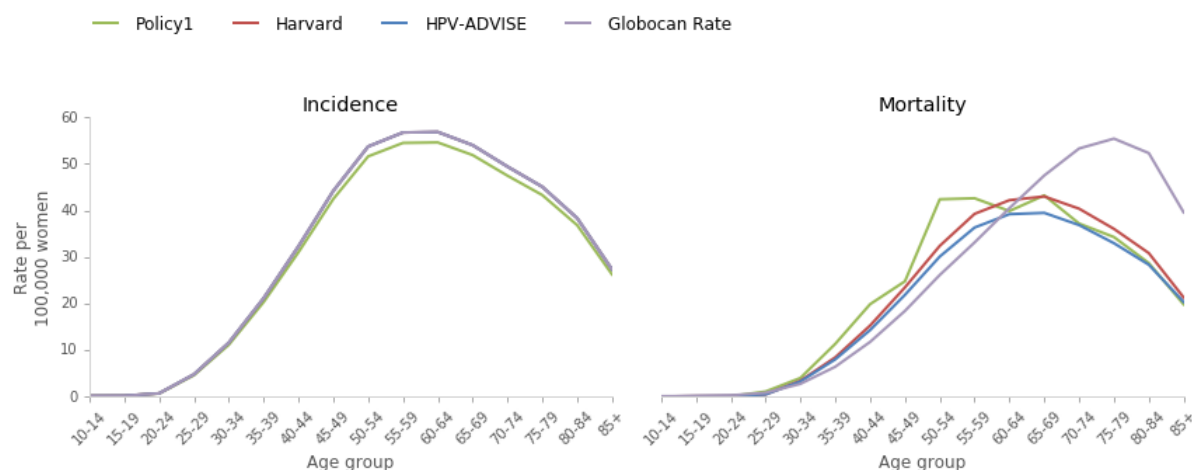
(a) All 78 LMICs



For these countries, the ASR using Globocan 2018 data is 19.8 for incidence and 13.3 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

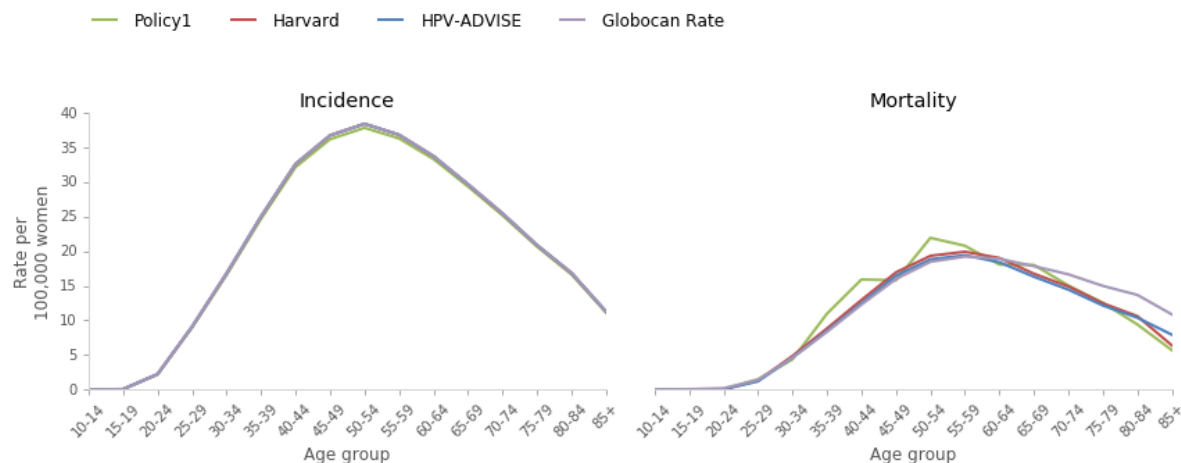
(b) Regional calibrations

(i) East Asia and Pacific



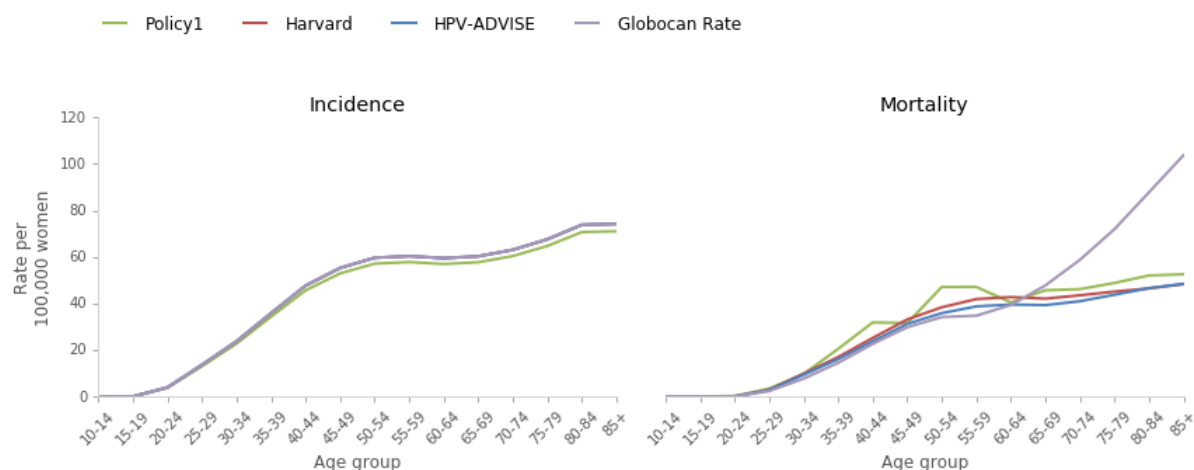
For these countries, the ASR using Globocan 2018 data is 19.9 for incidence and 12.0 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

(ii) Europe & Central Asia



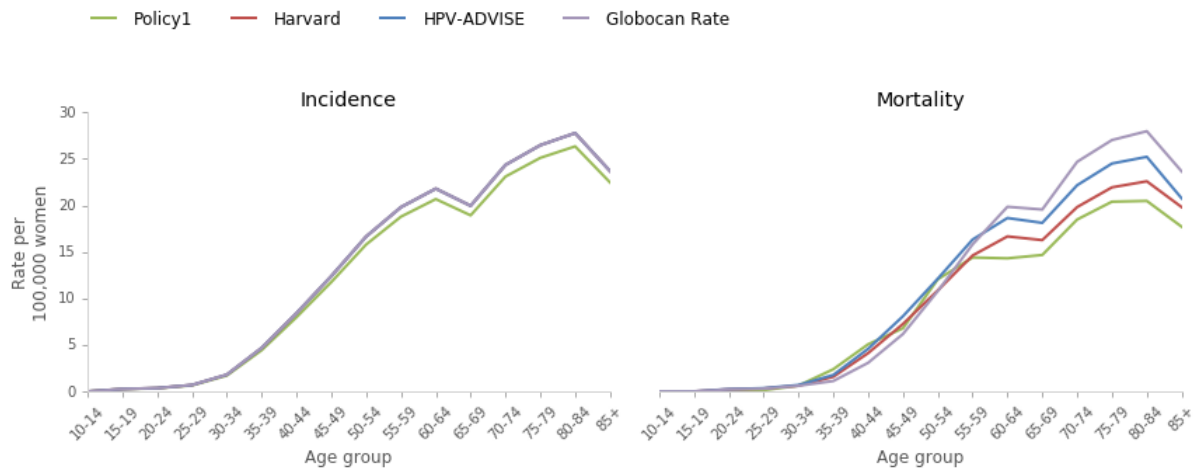
For these countries, the ASR using Globocan 2018 data is 15.7 for incidence and 7.0 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

(iii) Latin America & Caribbean



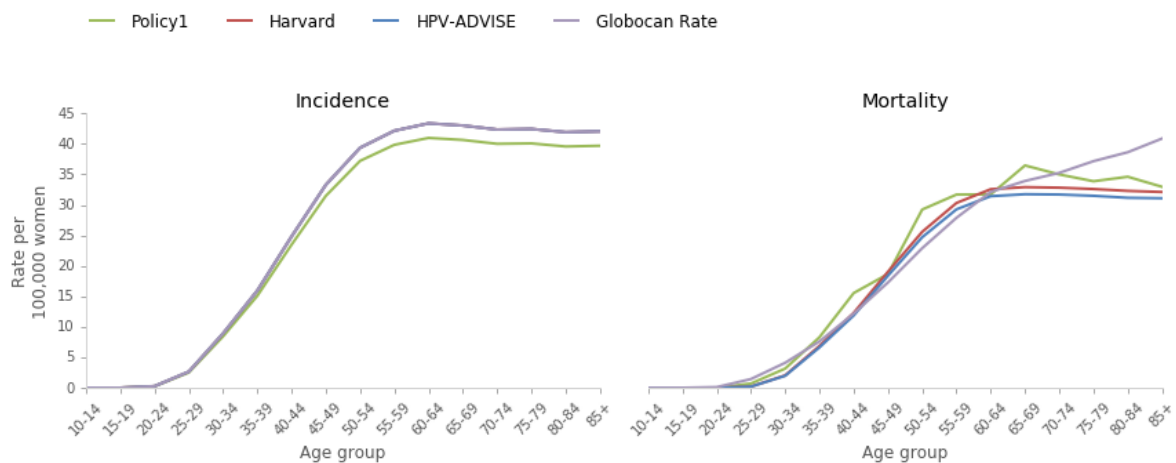
For these countries, the ASR using Globocan 2018 data is 26.8 for incidence and 16.3 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

(iv) Middle East & North Africa



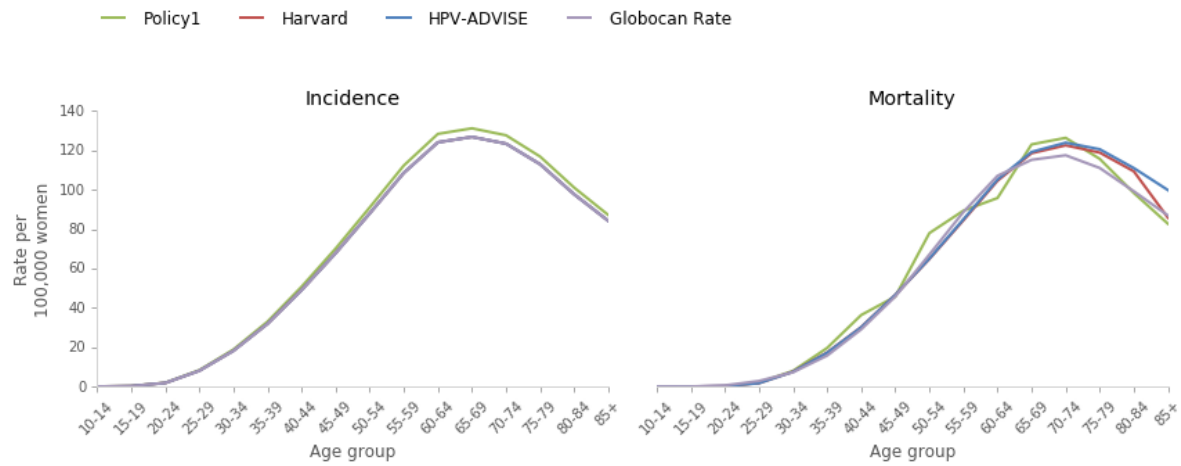
For these countries, the ASR using Globocan 2018 data is 6.8 for incidence and 5.1 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

(v) South Asia



For these countries, the ASR using Globocan 2018 data is 15.5 for incidence and 10.0 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

(vi) Sub-Saharan Africa



For these countries, the ASR using Globocan 2018 data is 37.4 for incidence and 29.0 for mortality when using 2015 World Female Population (WFP2015) for standardisation.

## Section 2. Detailed results for projected cervical cancer rates over time

**Table AR1. Reduction in cervical cancer mortality over time across all 78 LMIC countries.**

Relative reductions are compared to the *status quo* (S0) in that year. Results represent median (range) of estimates across all three models.

(a) Age-standardised rates (ASRs) per 100,000 women, for women aged 0-99 years

	S1		S2		S3		Supplementary S4		Supplementary S5	
Year	ASR Median (min-max)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)
2020	13.2 (12.8-14.0)	0.4 (0.0-0.6)	13.2 (12.8-14.0)	0.3 (0.0-0.6)	13.2 (12.8-14.1)	0.2 (0.0-0.5)	13.2 (12.8-14.0)	0.5 (0.0-0.5)	13.2 (12.8-14.0)	0.2 (0.0-0.7)
2030	13.2 (12.9-14.0)	0.1 (0.1-0.5)	8.5 (8.2-11.1)	34.3 (21.4-37.4)	8.5 (8.2-10.8)	34.2 (23.3-37.8)	13.1 (12.9-13.9)	0.2 (-0.3-1.5)	13.2 (13.0-14.1)	0.1 (-0.7-0.2)
2040	12.8 (12.5-13.6)	2.6 (2.5-3.1)	5.1 (5.1-6.4)	60.1 (54.8-61.6)	4.8 (4.5-5.4)	62.6 (61.9-65.5)	12.3 (12.0-12.3)	6.8 (4.4-14.5)	12.8 (12.6-13.6)	2.5 (2.3-3.6)
2050	11.2 (11.1-11.8)	16.1 (13.2-16.5)	3.8 (3.8-4.8)	70.9 (65.6-71.5)	3.1 (2.9-3.5)	75.9 (75.2-78.3)	9.0 (8.5-10.2)	31.5 (21.0-39.5)	11.1 (11.1-11.6)	16.0 (14.0-17.9)
2060	8.3 (7.8-8.5)	39.7 (35.5-41.2)	2.5 (2.5-3.5)	80.5 (74.9-80.8)	1.8 (1.6-2.4)	86.1 (83.2-87.6)	5.3 (5.1-6.8)	61.1 (47.6-62.7)	8.0 (7.8-8.2)	41.0 (38.1-41.8)
2070	5.0 (4.5-5.4)	61.7 (61.4-66.1)	1.4 (1.4-2.2)	88.9 (84.0-89.3)	1.0 (0.9-1.6)	92.3 (88.4-93.0)	3.2 (2.7-3.8)	77.5 (70.8-79.7)	4.5 (4.5-5.0)	65.3 (64.3-65.6)
2080	2.7 (2.4-3.2)	78.7 (77.0-81.5)	0.7 (0.7-1.3)	94.5 (90.8-94.8)	0.5 (0.5-1.0)	95.9 (93.2-96.4)	2.1 (1.6-2.2)	84.0 (83.4-87.7)	2.5 (2.2-2.8)	80.9 (80.1-82.9)
2090	1.7 (1.6-2.3)	86.6 (83.9-88.0)	0.4 (0.4-0.9)	97.0 (93.9-97.2)	0.3 (0.2-0.6)	97.8 (95.7-98.1)	1.5 (1.4-2.0)	88.4 (85.9-89.4)	1.6 (1.1-1.8)	87.6 (86.9-91.2)
2100	1.4 (1.4-2.0)	89.2 (85.8-89.5)	0.3 (0.3-0.7)	97.8 (94.8-97.9)	0.2 (0.2-0.5)	98.4 (96.4-98.5)	1.3 (1.3-1.9)	89.6 (86.5-89.8)	1.4 (0.8-1.6)	89.4 (88.7-94.0)
2110	1.3 (1.3-1.9)	89.8 (86.3-89.8)	0.3 (0.3-0.7)	97.9 (95.0-98.1)	0.2 (0.2-0.5)	98.5 (96.4-98.6)	1.3 (1.3-1.9)	89.5 (86.7-89.9)	1.3 (0.7-1.6)	89.8 (88.9-94.6)
2120	1.3 (1.3-1.9)	89.5 (86.6-89.9)	0.3 (0.3-0.7)	97.9 (95.0-98.0)	0.2 (0.2-0.5)	98.6 (96.5-98.6)	1.3 (1.3-1.8)	89.7 (86.9-89.9)	1.3 (0.7-1.5)	89.9 (89.2-94.6)

(b) Age-standardised rates (ASRs) per 100,000 women, for women aged 30-69 years (premature mortality)

Year	S1		S2		S3		Supplementary S4		Supplementary S4	
	ASR Median (min-max)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)	ASR Median (range)	% reduction vs S0 Median (range)
2020	23.7 (22.9-25.5)	0.6 (0.0-0.9)	23.7 (22.9-25.6)	0.2 (0.0-0.6)	23.7 (23.0-25.6)	0.2 (0.0-0.5)	23.7 (22.9-25.5)	0.6 (0.0-0.7)	23.7 (22.9-25.6)	0.2 (0.0-0.7)
2030	23.7 (23.0-25.5)	0.2 (0.0-0.5)	15.2 (14.8-20.0)	34.2 (22.1-37.4)	15.2 (14.7-19.4)	33.9 (24.4-37.9)	23.6 (23.1-25.3)	0.1 (-0.2-1.4)	23.7 (23.3-25.6)	0.0 (-0.8-0.1)
2040	23.0 (22.4-24.7)	2.8 (2.7-3.4)	9.0 (8.9-11.2)	60.8 (56.3-62.5)	8.3 (7.7-8.9)	65.2 (64.0-67.4)	21.8 (21.1-21.9)	7.8 (5.0-17.4)	23.0 (22.6-24.6)	2.7 (2.2-3.8)
2050	19.4 (19.1-20.5)	19.2 (16.1-19.9)	6.0 (5.9-7.8)	74.3 (69.4-74.7)	4.6 (4.1-5.0)	80.6 (80.1-82.5)	14.7 (13.5-17.1)	37.9 (25.9-47.3)	19.2 (19.1-20.1)	19.2 (16.8-21.5)
2060	12.9 (11.9-13.2)	48.5 (44.1-49.6)	3.4 (3.2-5.0)	85.5 (80.6-86.0)	2.1 (1.9-2.9)	90.8 (88.9-91.9)	6.5 (6.5-9.4)	72.6 (59.1-74.8)	12.1 (12.0-12.6)	49.4 (47.4-51.1)
2070	5.5 (5.1-6.2)	76.1 (75.7-78.5)	1.3 (1.2-2.3)	94.4 (91.1-94.6)	0.9 (0.8-1.4)	96.2 (94.3-96.8)	3.3 (3.1-3.9)	85.9 (84.9-86.8)	5.2 (4.4-5.4)	78.9 (77.9-81.0)
2080	2.7 (2.2-3.8)	88.4 (85.0-90.6)	0.6 (0.4-1.3)	97.6 (95.1-98.3)	0.4 (0.4-0.9)	98.4 (96.7-98.4)	2.6 (2.2-3.6)	89.0 (85.9-90.7)	2.9 (1.0-3.0)	88.2 (87.6-95.5)
2090	2.5 (2.0-3.7)	89.3 (85.5-91.2)	0.5 (0.4-1.2)	97.9 (95.2-98.4)	0.3 (0.3-0.8)	98.5 (96.8-98.7)	2.5 (2.0-3.6)	89.6 (86.1-91.2)	2.6 (1.0-2.9)	89.0 (88.5-95.9)
2100	2.4 (2.0-3.6)	89.8 (86.0-91.2)	0.5 (0.4-1.2)	98.0 (95.4-98.4)	0.3 (0.3-0.8)	98.6 (96.9-98.8)	2.4 (2.0-3.5)	89.9 (86.5-91.2)	2.4 (0.9-2.9)	89.7 (88.8-96.1)
2110	2.4 (2.0-3.5)	89.9 (86.3-91.4)	0.5 (0.4-1.2)	98.0 (95.4-98.4)	0.3 (0.3-0.8)	98.6 (96.9-98.8)	2.4 (2.1-3.4)	89.9 (86.6-91.1)	2.4 (0.9-2.8)	89.9 (89.0-96.2)
2120	2.4 (2.1-3.4)	89.9 (86.6-91.1)	0.5 (0.4-1.2)	98.0 (95.5-98.3)	0.3 (0.3-0.8)	98.6 (96.9-98.8)	2.4 (2.0-3.4)	89.9 (86.8-91.2)	2.4 (0.9-2.8)	89.9 (89.2-96.2)

(c) Relative reductions in premature mortality (vs. status quo) estimated using probability of dying between the ages of 30 and 70 years. Relative reductions are also similar if estimated as the probability of death in 2030 vs death in 2020 for the same strategy. Methods for estimating probability of death as defined for UN SDG Indicator 3.4.1 [<https://unstats.un.org/sdgs/metadata/files/Metadata-03-04-01.pdf>].

	S1	S2	S3	Supplementary S4	Supplementary S4
	% reduction vs S0 Median (range)	% reduction vs S0 Median (range)	% reduction vs S0 Median (range)	% reduction vs S0 Median (range)	% reduction vs S0 Median (range)
2030	0.4 (0.0 - 0.4)	35.1 (21.6 - 37.9)	34.8 (23.6 - 38.3)	0.2 (0.0 - 1.1)	0.0 (-0.7 - 0.0)
2070	69.9 (68.5 - 72.0)	93.0 (88.8 - 93.4)	95.6 (92.0 - 96.3)	83.6 (82.5 - 84.3)	73.2 (71.6 - 73.3)
2120	88.2 (84.1 - 89.1)	98.0 (94.9 - 98.4)	98.7 (96.5 - 98.9)	88.2 (85.3 - 89.2)	88.2 (87.5 - 94.7)

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination; S2 = female-only vaccination and once-lifetime HPV testing at age 35 and treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 and treatment scale-up; Supplementary S4 = female-only vaccination with multi-age cohort (MAC) catch-up to 25 years in 2020; Supplementary S5 = female and male vaccination. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types 16/18/31/33/45/52/58. Population projections were obtained from the UN and further projected out to 2120 (see **Technical Appendix**).

Model methods incorporate randomness and heterogeneity in estimates which can on occasion over shorter term time frames lead to relative increases rather than decreases in rates compared to the status quo, shown here as negative values. Randomness and heterogeneity can also lead to slight decreases in the percentage reduction in predicted rates even in the first year modelled (2020) and small differences from the expected relative ordering of the impact of different scenarios or the expected relative reductions over time. Caution should be applied in interpreting comparative differences between the values in this table which represent median and range across models; any individual median result could represent the findings of any one of the CCEMC models. Note that the sum of averted cases and cases predicted for a given strategy may also not be identical to cases predicted for S0 because of rounding.

### Section 3. Age-specific cervical cancer incidence and mortality rate results for each model

Figure AR2 shows the model and age-specific results for cervical cancer incidence and mortality in 2020, 2070 and 2120 for all 78 LMICs and by region.

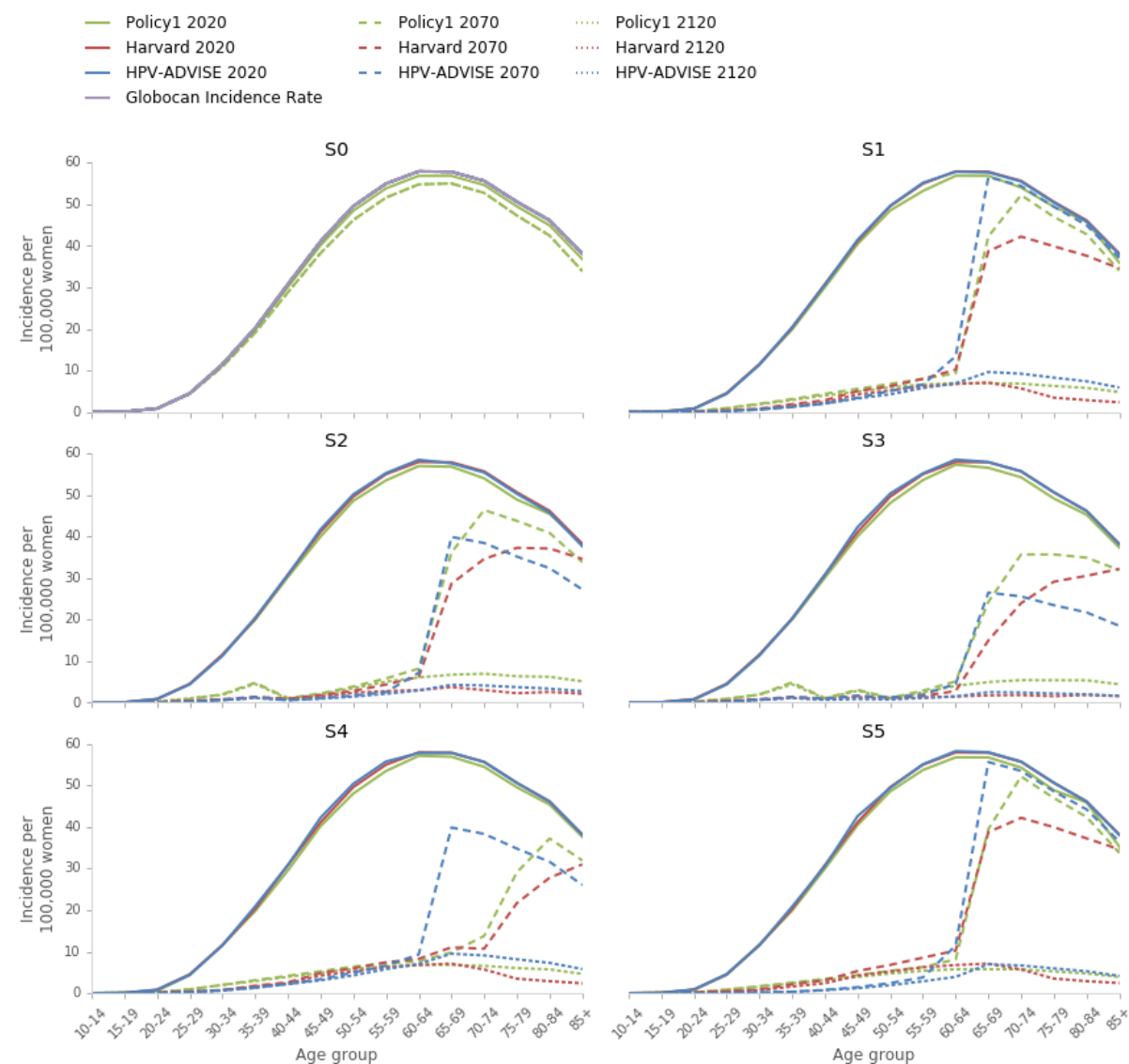
Overall findings were very concordant between models. The only notable difference is in the level of herd immunity predicted at older ages for unvaccinated individuals, with the Harvard model showing the highest level and the *Policy1-Cervix* model the lowest. These differences likely relate to underlying differences in assumptions around assortative sexual mixing among different age groups and different behaviour groups; we consider that the model variation in this area provides a useful reflection of true uncertainty in outcomes.

With girls-only vaccination, even by 2070 the oldest cohorts (then aged over 65 years) will not have been offered vaccination and hence will only be impacted by herd immunity (to a degree which varies according to model). By 2120, results across age groups are more homogenous, since by this time all age cohorts have been offered vaccination. For the WHO triple-intervention strategy, the 2070 and 2120 rates in older women are lower than those for vaccination alone, due to the effects of screening and treatment.

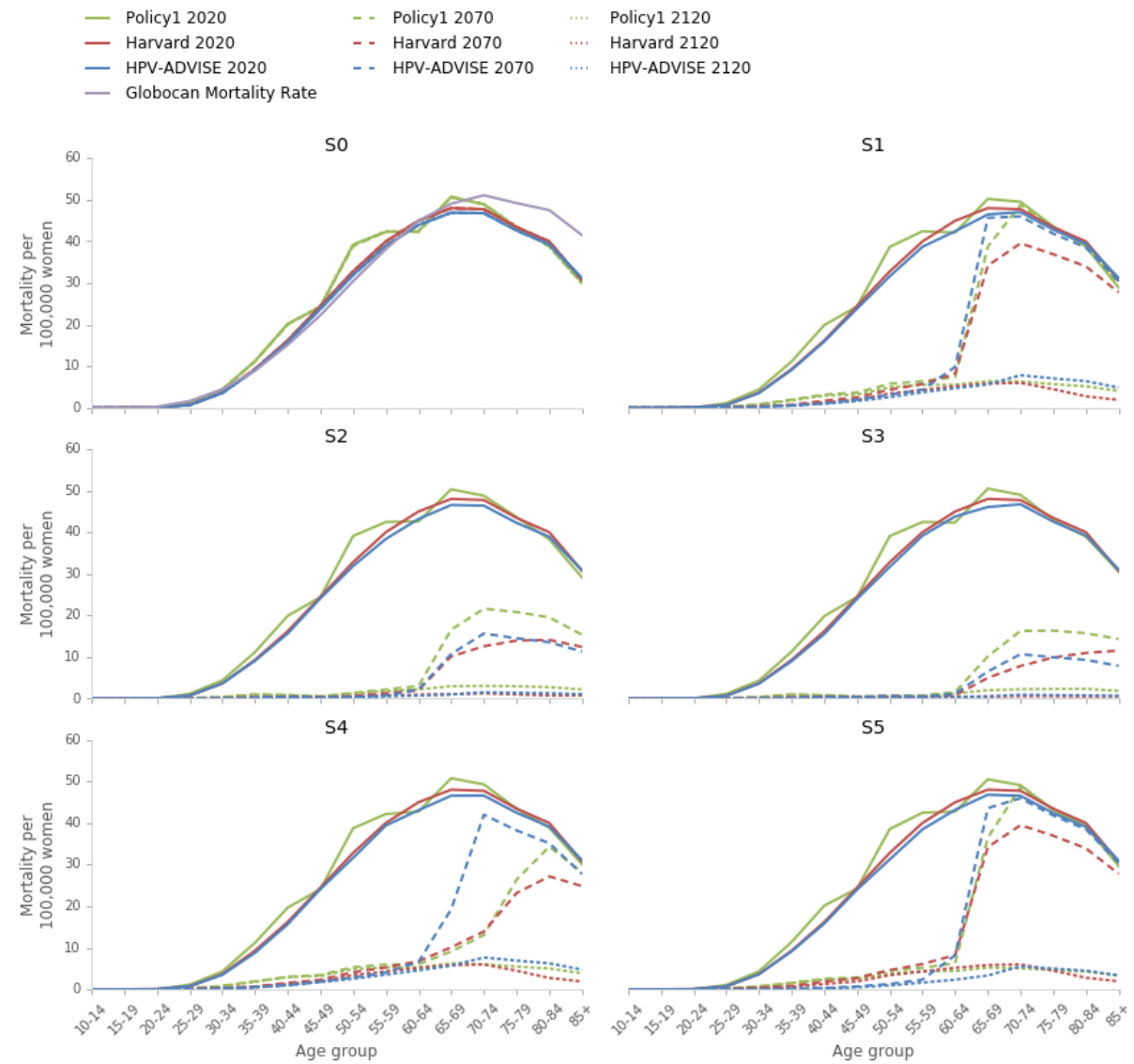
**Figure AR2. ‘Snapshots’ of age-specific cervical cancer incidence and mortality rates across (a) all 78 LMIC countries; (b) regional results (i) East Asia & Pacific, (ii) Europe & Central Asia, (iii) Latin America & Caribbean, (iv) Middle East & North Africa, (v) South Asia, (vi) Sub-Saharan Africa.**

(a) Age-specific rates for all 78 LMICs

Incidence



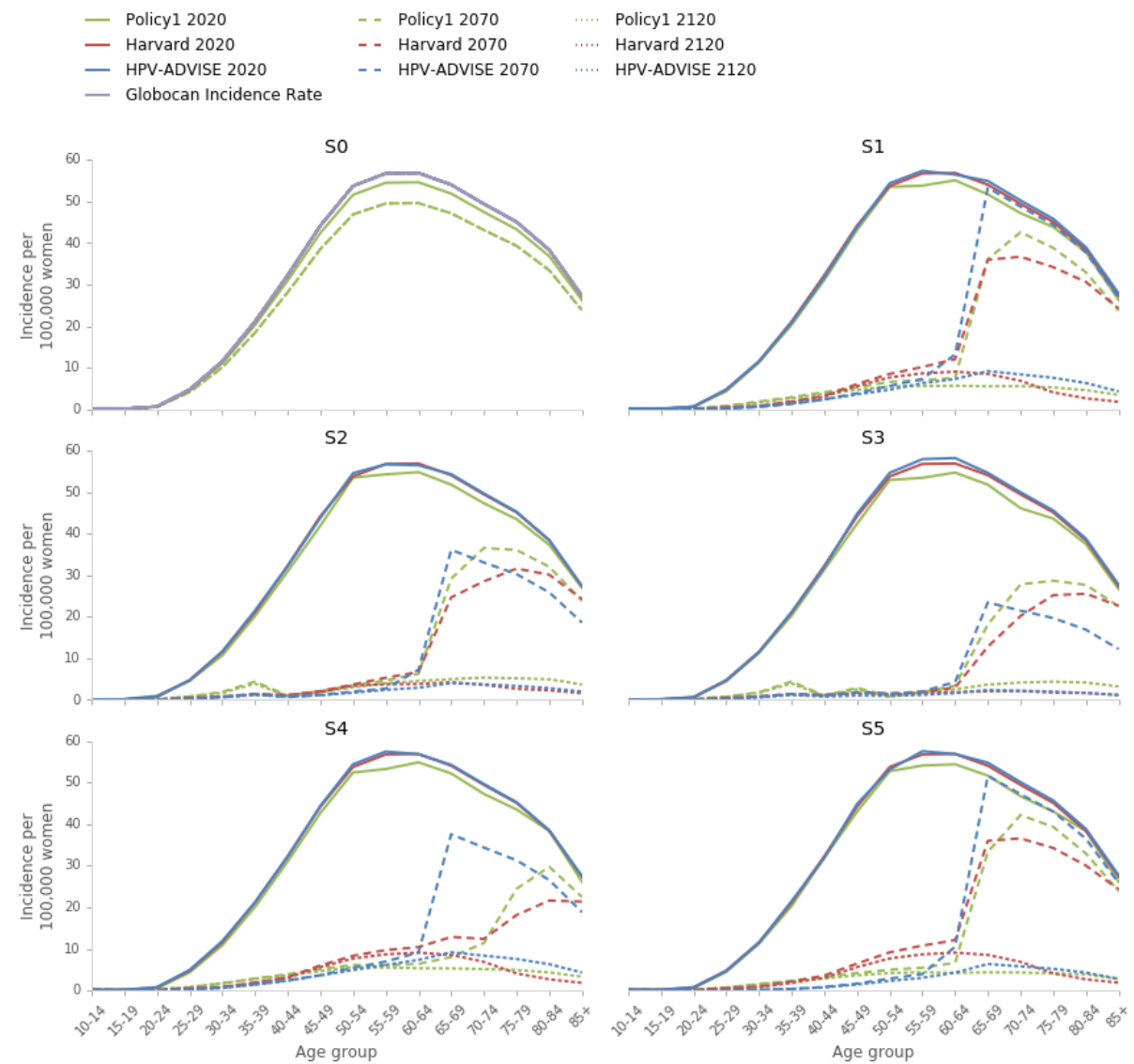
## Mortality



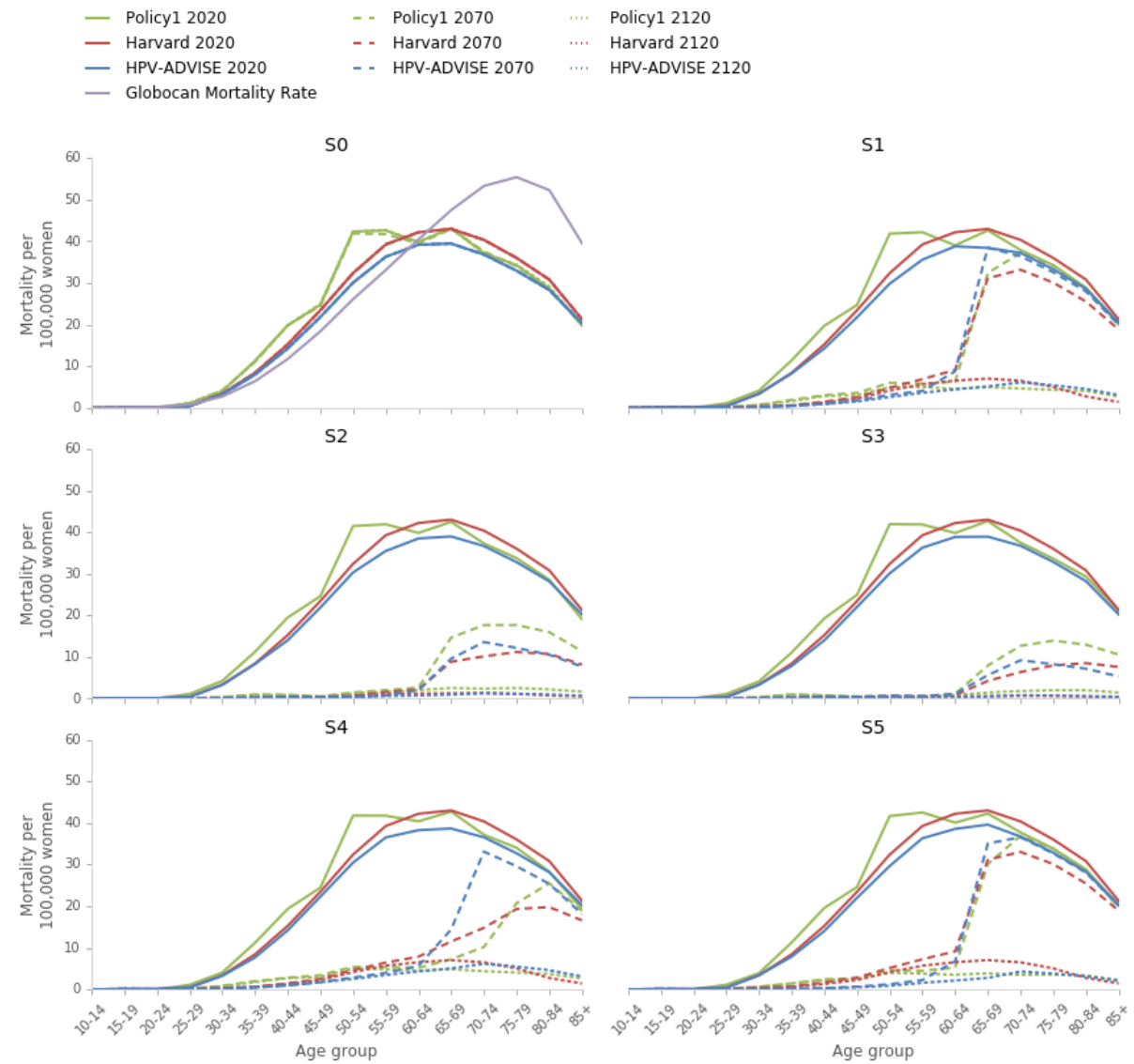
(b) Age-specific rates for each region

(i) East Asia & Pacific

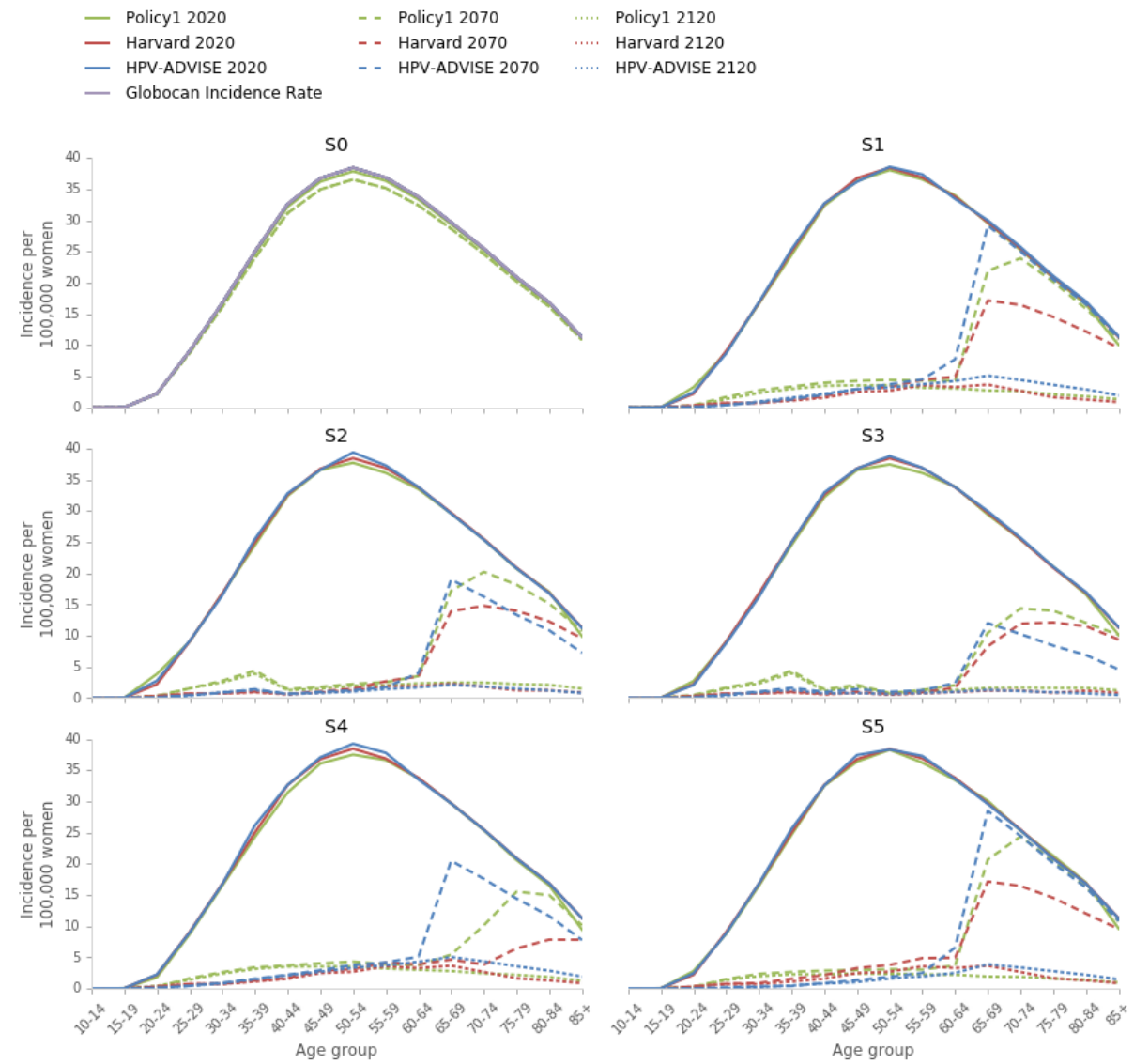
Incidence



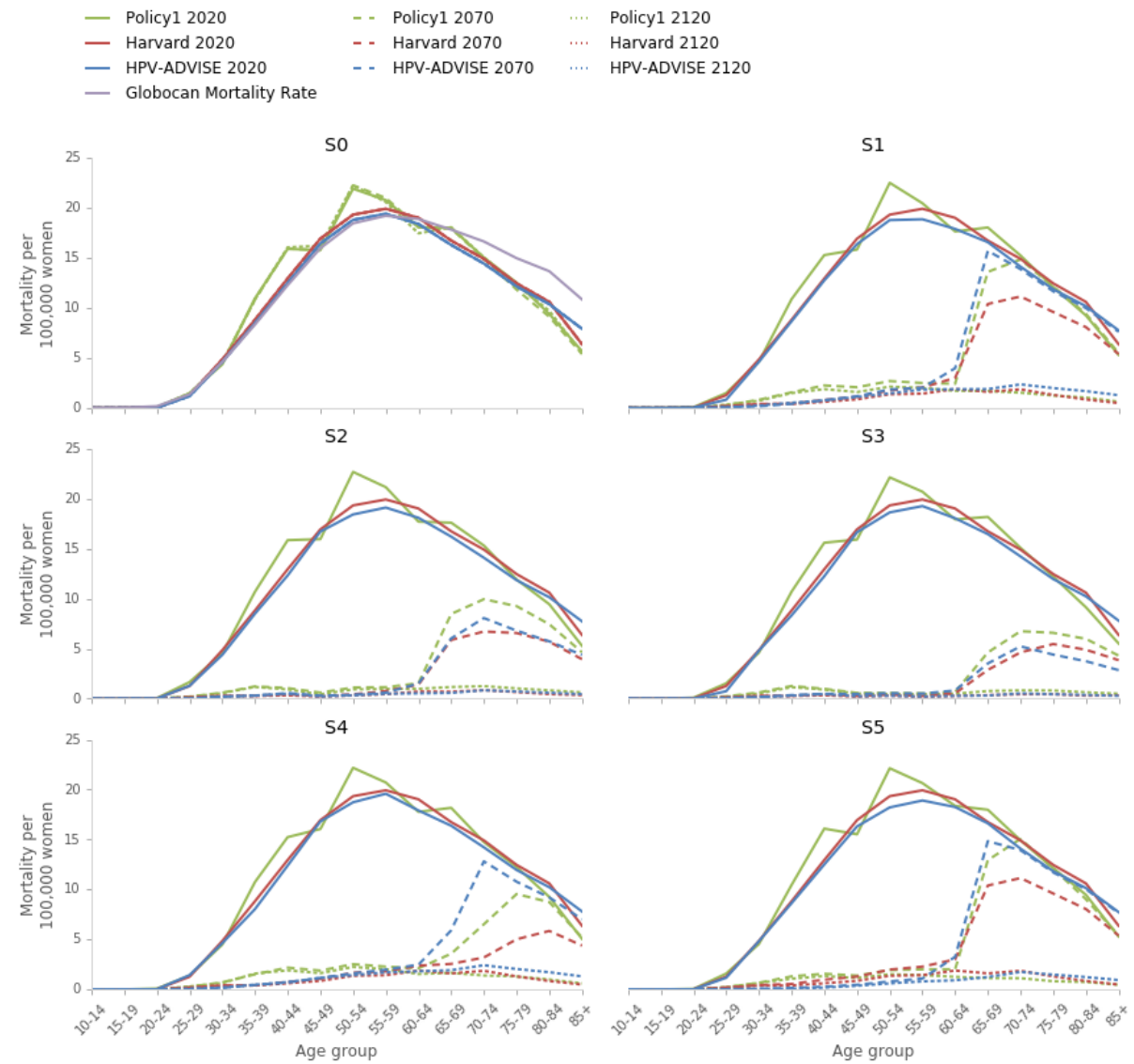
## Mortality



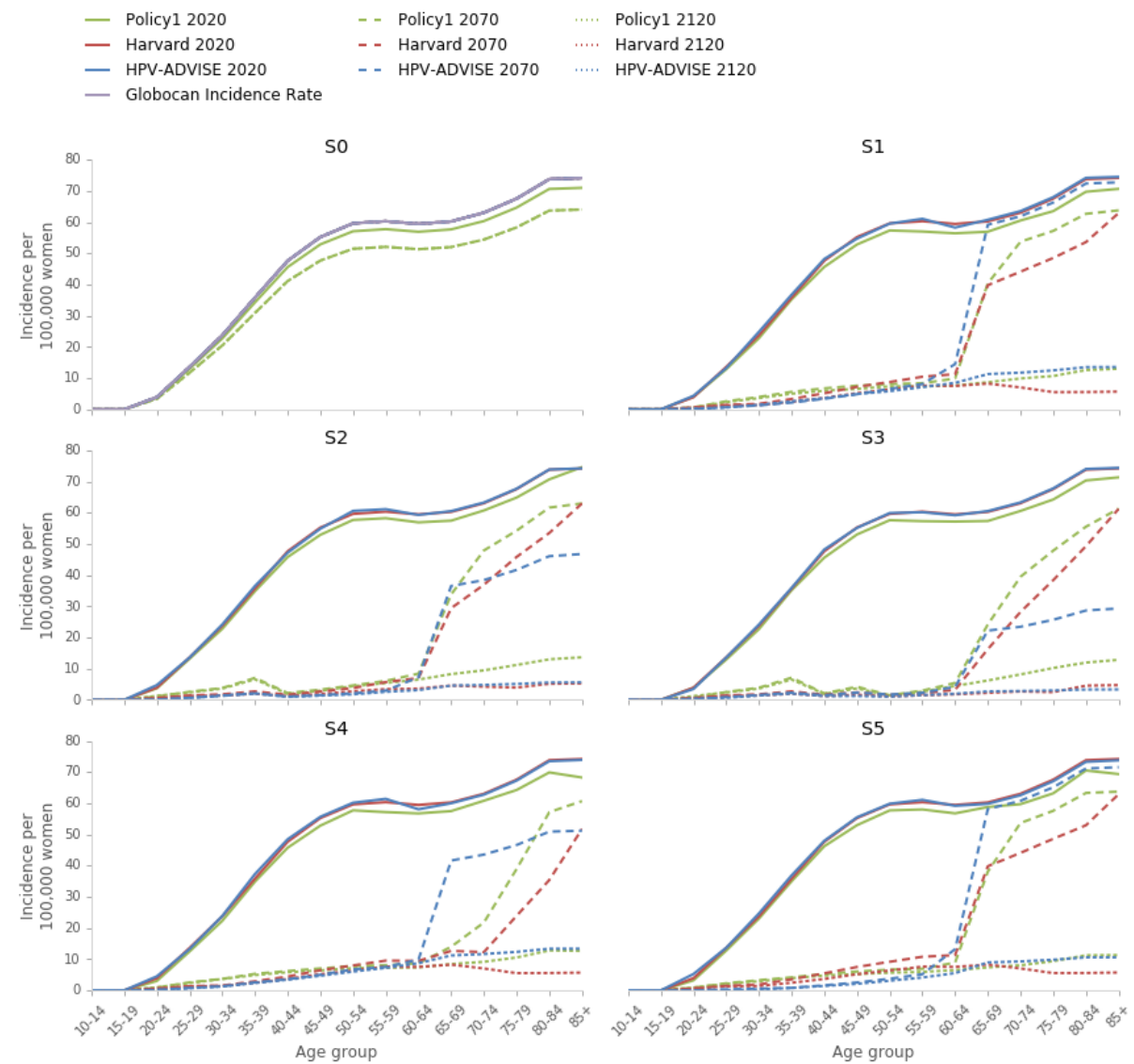
(ii) Europe & Central Asia  
Incidence



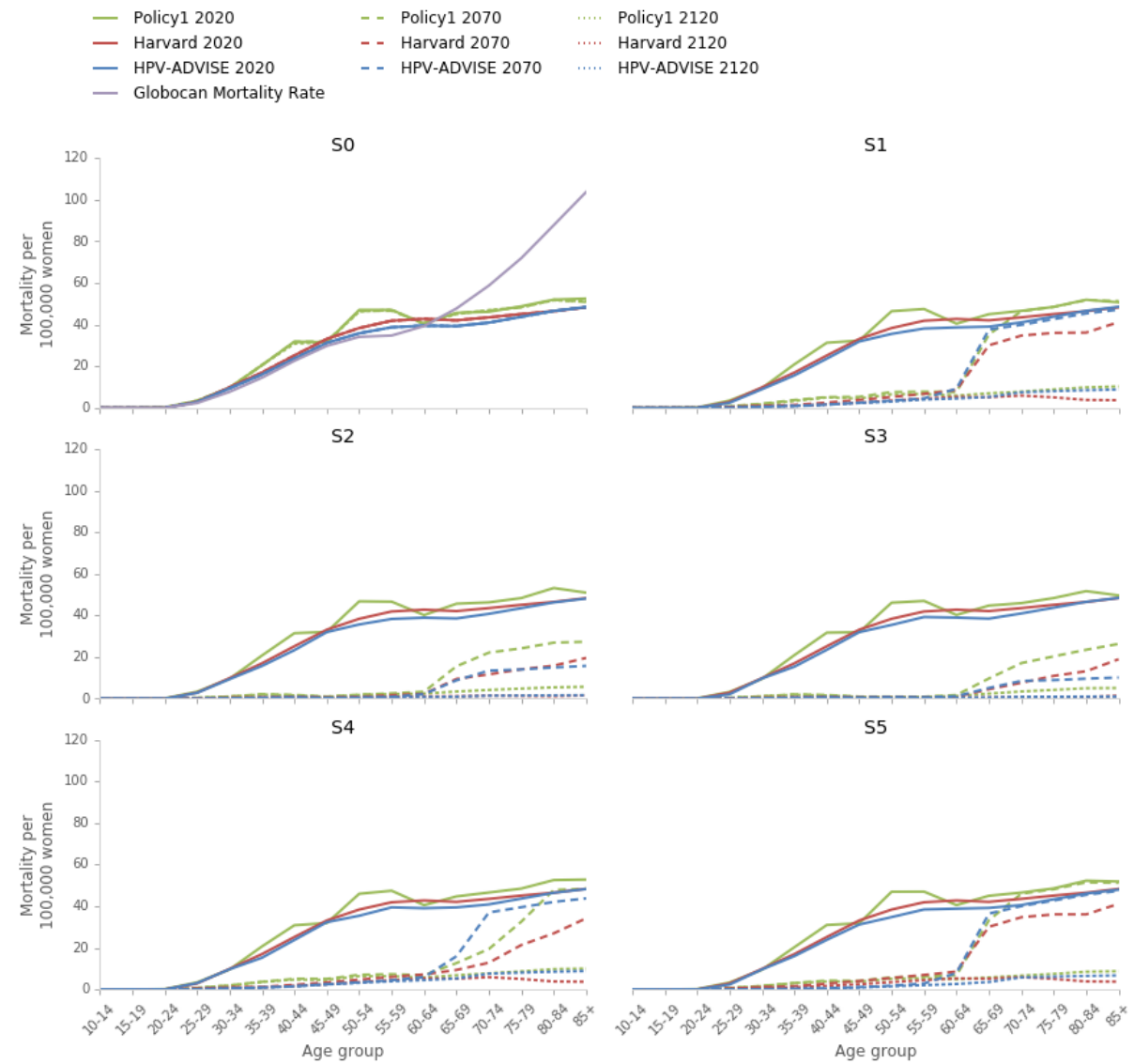
## Mortality



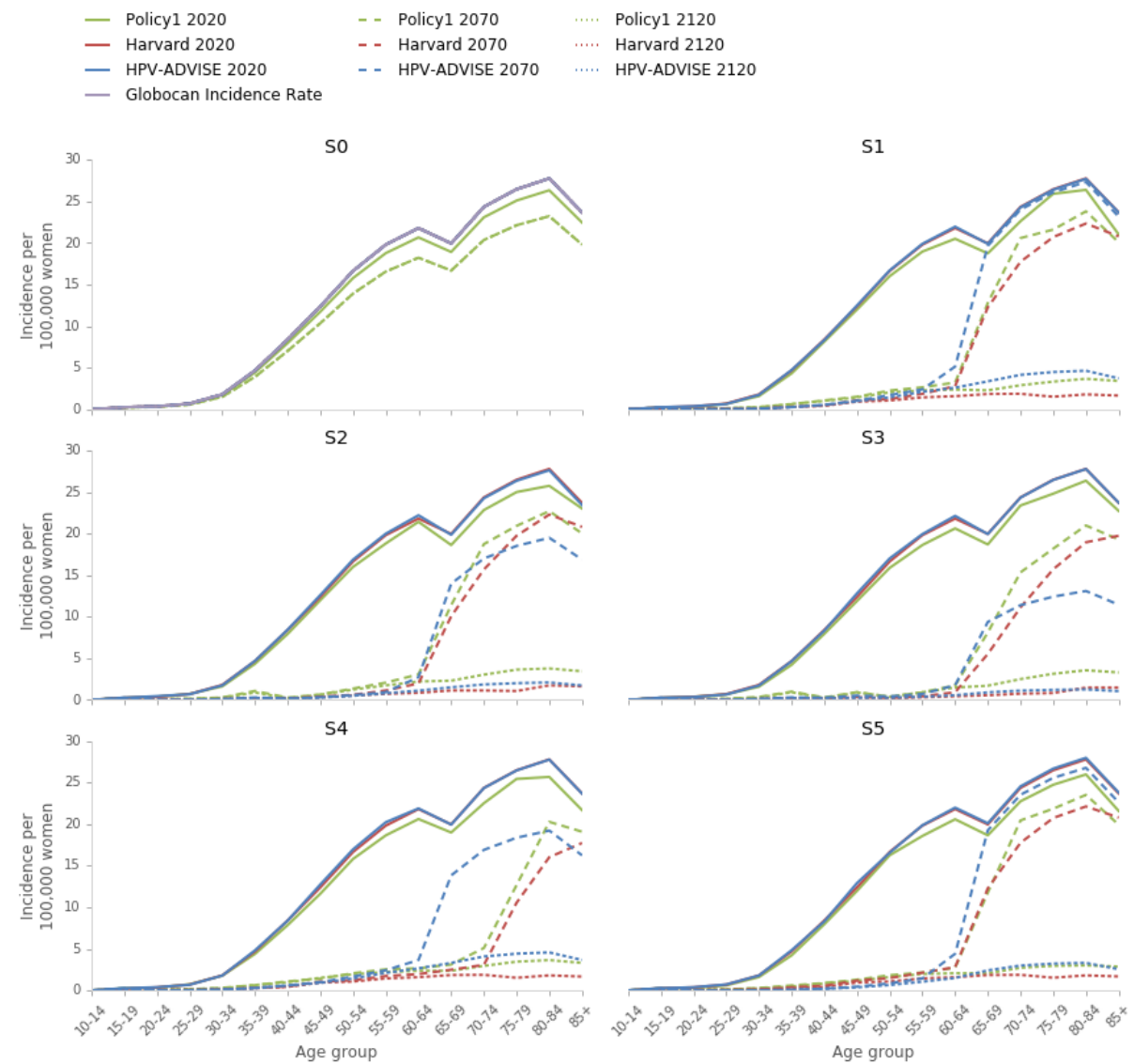
(iii) Latin America & Caribbean  
Incidence



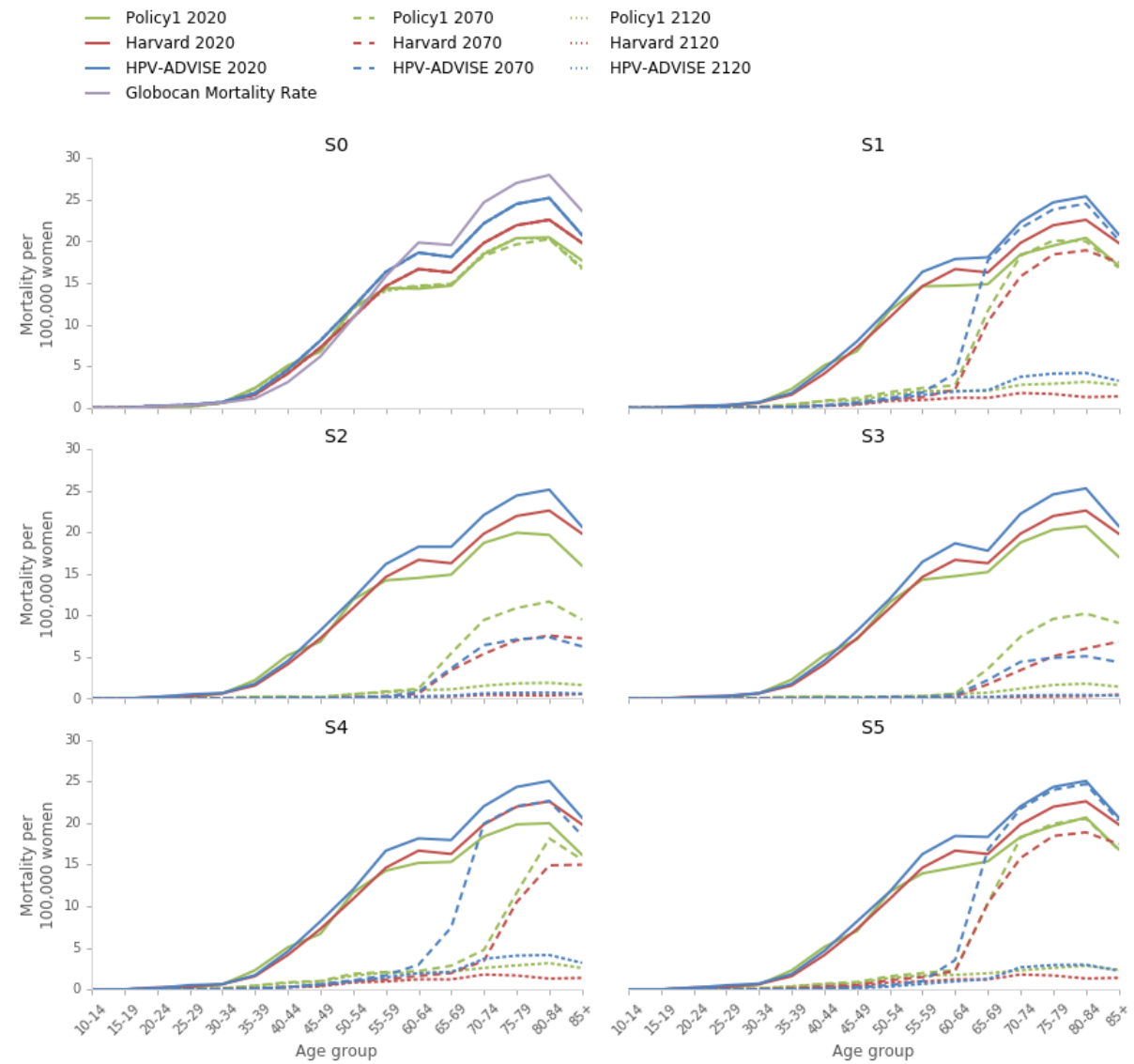
## Mortality



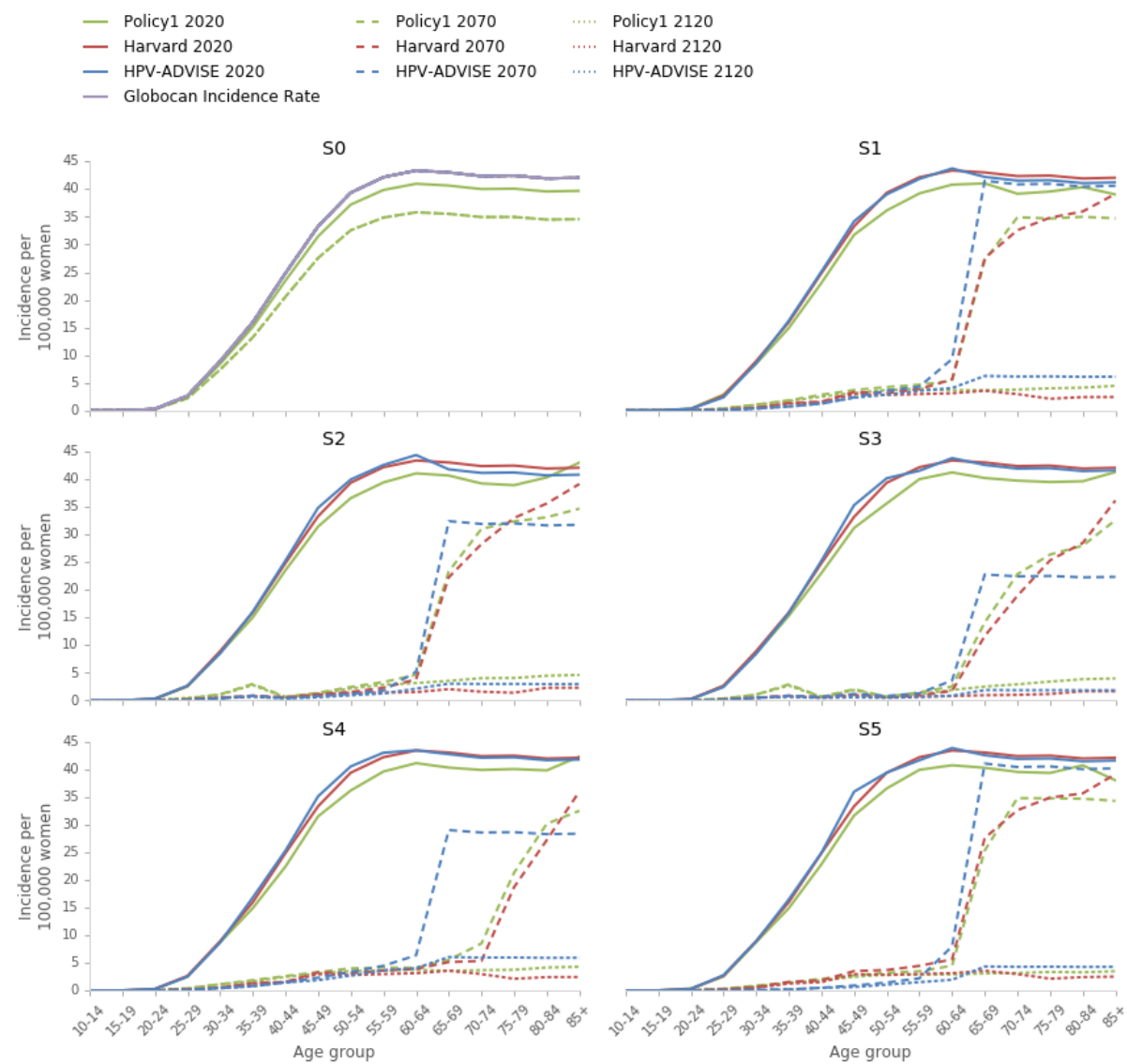
(iv) Middle East & North Africa  
Incidence



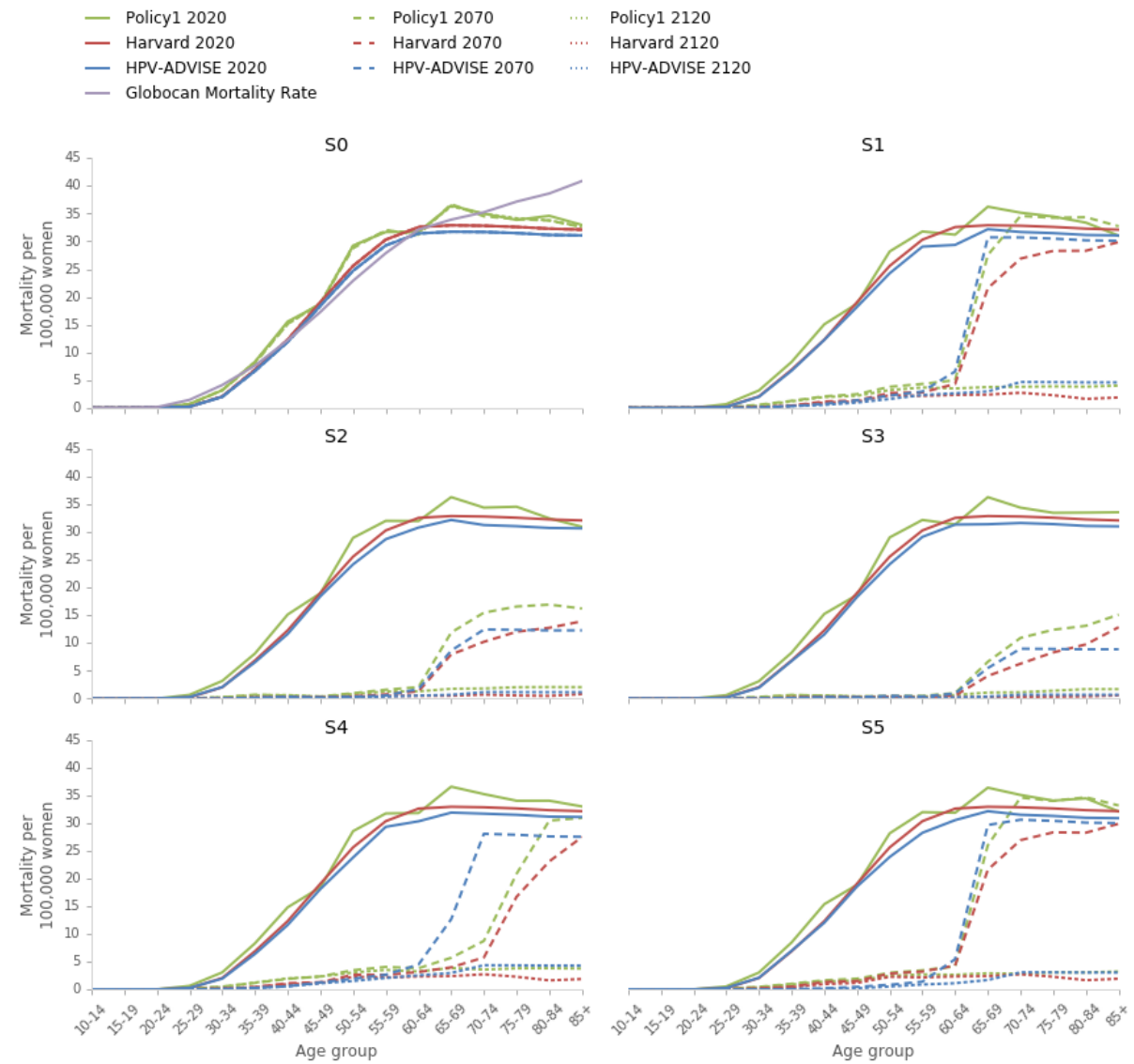
## Mortality



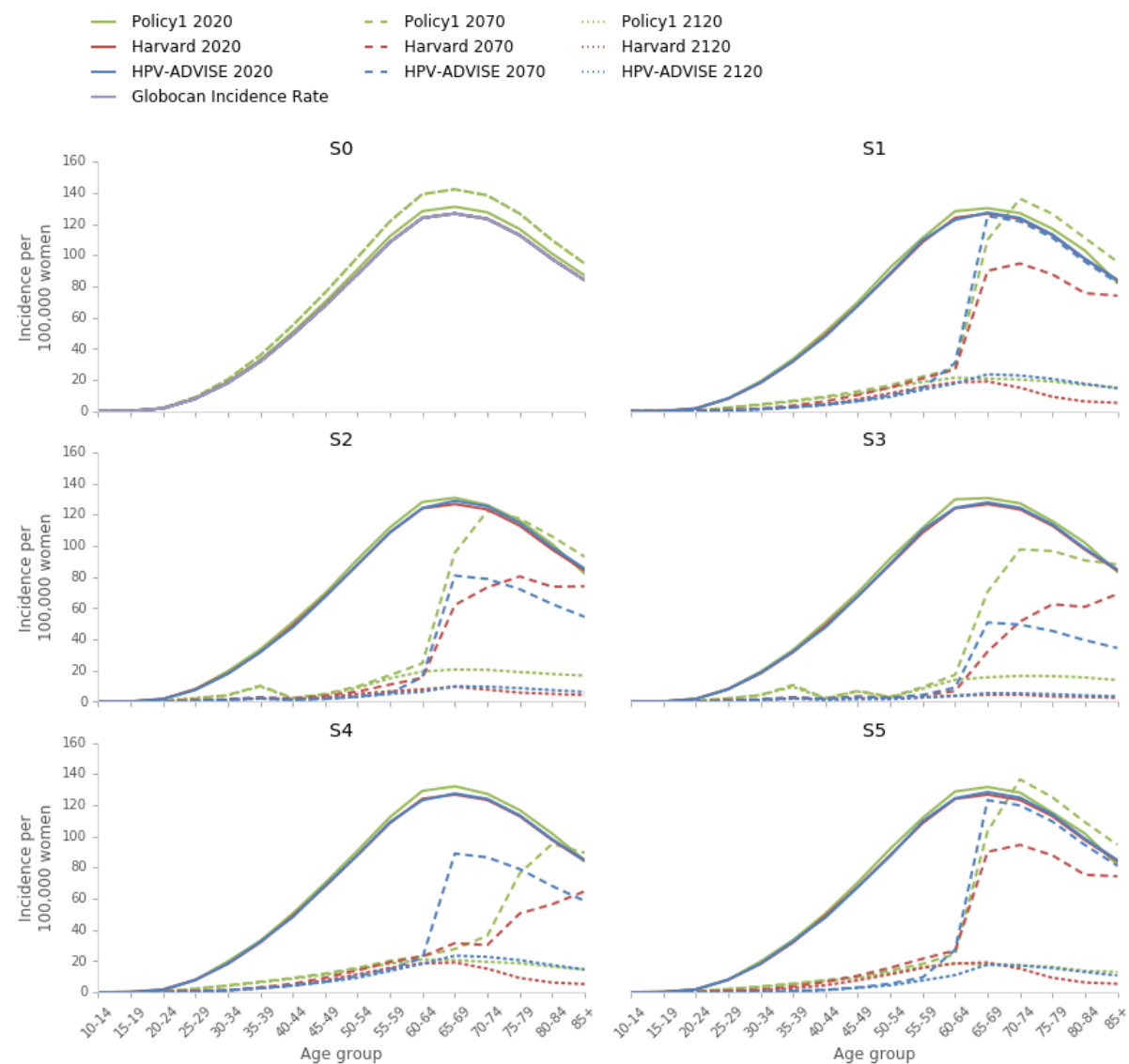
(v) South Asia  
Incidence



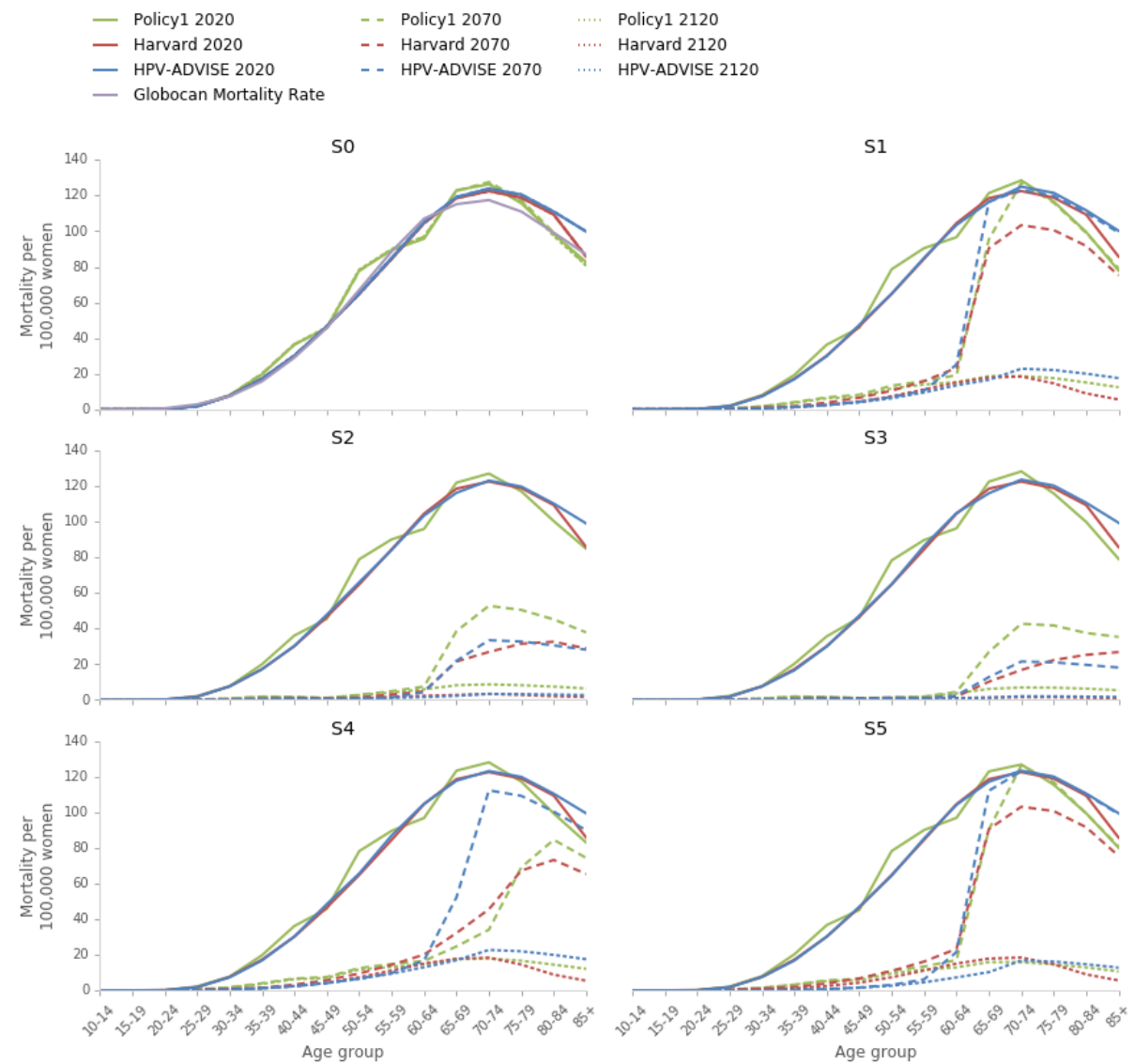
## Mortality



(vi) Sub-Saharan Africa  
Incidence



## Mortality



#### Section 4. Deaths averted by region for the triple-intervention strategy S3

**Table AR2. Cumulative cervical cancer deaths averted (millions) for the triple-intervention scenario S3 across all-78 LMIC countries, and by region, over three time periods.**

	All 78 LMICs	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub-Saharan Africa
By 2030 (2020-2030)	0.3 (0.3-0.4)	0.0 (0.0-0.1)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.1 (0.1-0.1)	0.1 (0.1-0.2)
% of averted deaths in All-78 LMICs	-	16% (13-18%)	0% (0-1%)	1% (1-1%)	3% (1-3%)	32% (29-34%)	48% (45-55%)
By 2070 (2020-2070)	14.6 (14.1-14.6)	1.8 (1.6-1.8)	0.1 (0.1-0.1)	0.2 (0.2-0.2)	0.2 (0.2-0.3)	4.2 (3.9-4.4)	8.0 (7.9-8.1)
% of averted deaths in All-78 LMICs	-	12% (11-13%)	1% (1-1%)	1% (1-1%)	2% (1-2%)	29% (28-30%)	55% (54-57%)
By 2120 (2020-2120)	62.6 (62.1-62.8)	5.3 (4.9-5.4)	0.3 (0.3-0.3)	0.5 (0.5-0.5)	0.8 (0.7-0.9)	12.4 (11.8-12.7)	43.5 (43.0-43.7)
% of averted deaths in All-78 LMICs	-	9% (8-9%)	1% (0-1%)	1% (1-1%)	1% (1-1%)	20% (19-20%)*	69% (69-70%)*

Population projections were obtained from the UN and further projected out to 2120 (see **Technical Appendix**). The median for deaths is the median of three possible model outputs for a given time-period; similarly, the median for ‘deaths averted’ and ‘% reduction vs S0’ is the median model selected after calculation, and may be different to the median model selected for total deaths metric, and may also be different across the different time-periods. Caution should be applied in interpreting comparative differences between the values in this table which represent median and range across models; any individual median result could represent the findings of any one of the CCEMC models. \*Note that the explicit calculation of the sum of the proportions of cumulative deaths averted in South Asia and Sub-Saharan Africa by 2120 is 89% (89-89%)

## Section 5. Country-level results

**Table AR3. Country-level results.**

Deaths and age-standardised rates (ASRs) are presented as median (range) of model outputs. Countries listed alphabetically.

	World Bank Region	Cervical cancer deaths from 2020-2070 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2070 if S3 [% of all 78 LMICs]	ASR mortality (S0), 2120	ASR mortality (S3), 2120	Cervical cancer deaths from 2020-2120 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2120 if S3 [% of all 78 LMICs]	Cervical cancer deaths averted from 2020-2120 if S3 [% of all 78 LMICs]
<b>All 78 countries</b>		20,747,296 (20,407,113-21,951,485)	6,354,834 (6,108,349-7,394,121)	13.2 (12.9-14.1)	0.2 (0.2-0.5)	70,133,715 (69,748,457-72,950,793)	7,642,668 (7,289,210-10,301,924)	62,648,868 (62,105,789-62,844,504)
<b>Afghanistan</b>	South Asia	67,933 (61,125-72,534) [0.3%]	16,313 (15,996-17,794) [0.3%]	5.4 (4.8-5.7)	0.1 (0.1-0.1)	203,960 (178,494-218,901) [0.3%]	20,821 (18,394-21,108) [0.3%]	185,565 (157,673-197,792) [0.3%]
<b>Angola</b>	Sub-Saharan Africa	343,076 (321,134-379,865) [1.7%]	90,789 (85,264-110,484) [1.4%]	31.8 (29.7-35.0)	0.6 (0.5-1.5)	1,812,613 (1,696,444-1,996,469) [2.6%]	127,091 (122,024-202,525) [1.7%]	1,685,521 (1,574,420-1,793,943) [2.7%]
<b>Arab Republic of Egypt</b>	Middle East & North Africa	70,652 (68,447-72,131) [0.3%]	23,511 (21,129-30,150) [0.4%]	1.8 (1.7-1.8)	0.0 (0.0-0.1)	223,696 (217,606-227,913) [0.3%]	29,209 (26,945-45,653) [0.4%]	190,660 (178,042-198,703) [0.3%]
<b>Bangladesh</b>	South Asia	505,703 (502,021-531,608) [2.4%]	182,851 (176,804-184,427) [2.9%]	8.0 (7.8-8.3)	0.1 (0.1-0.2)	1,065,203 (1,042,859-1,119,503) [1.5%]	206,090 (195,834-216,701) [2.7%]	859,113 (826,157-923,668) [1.4%]
<b>Benin</b>	Sub-Saharan Africa	88,307 (76,103-90,892) [0.4%]	20,201 (19,440-31,222) [0.3%]	24.7 (21.3-25.1)	0.3 (0.2-1.1)	401,856 (346,620-409,443) [0.6%]	26,039 (24,335-51,438) [0.3%]	358,004 (322,284-375,816) [0.6%]
<b>Bhutan</b>	South Asia	3,224 (2,876-3,407) [0.0%]	981 (976-1,073) [0.0%]	10.8 (9.9-11.3)	0.1 (0.1-0.3)	6,717 (5,809-7,410) [0.0%]	1,111 (1,065-1,203) [0.0%]	5,652 (4,698-6,207) [0.0%]
<b>Bolivia</b>	Latin America & Caribbean	105,636 (74,145-112,931) [0.5%]	35,191 (32,616-39,991) [0.6%]	25.2 (17.7-27.3)	0.4 (0.4-1.3)	257,284 (181,462-267,846) [0.4%]	39,505 (36,571-49,390) [0.5%]	217,778 (144,891-218,455) [0.3%]
<b>Burkina Faso</b>	Sub-Saharan Africa	279,501 (278,389-307,611) [1.3%]	65,002 (60,695-78,231) [1.0%]	41.8 (41.4-46.3)	0.5 (0.4-1.7)	1,257,119 (1,243,394-1,391,194) [1.8%]	83,713 (77,043-127,560) [1.1%]	1,180,076 (1,115,833-1,307,480) [1.9%]
<b>Burundi</b>	Sub-Saharan Africa	213,438 (206,388-233,529) [1.0%]	49,919 (46,998-56,912) [0.8%]	53.6 (51.8-58.7)	0.7 (0.7-2.2)	995,705 (962,368-1,090,684) [1.4%]	65,334 (61,277-96,422) [0.9%]	934,428 (865,945-1,025,350) [1.5%]
<b>Cabo Verde</b>	Sub-Saharan Africa	3,630 (1,724-3,816) [0.0%]	1,037 (873-1,283) [0.0%]	16.4 (8.0-17.7)	0.2 (0.2-0.8)	8,597 (4,256-9,256) [0.0%]	1,191 (1,024-1,653) [0.0%]	6,944 (3,232-8,065) [0.0%]
<b>Cambodia</b>	East Asia & Pacific	72,612 (68,707-74,708) [0.3%]	22,531 (21,833-26,745) [0.4%]	11.1 (10.7-11.5)	0.1 (0.1-0.4)	188,960 (176,281-194,926) [0.3%]	26,492 (25,400-35,416) [0.3%]	162,467 (140,864-169,525) [0.3%]
<b>Cameroon</b>	Sub-Saharan Africa	243,881 (217,486-248,488) [1.2%]	54,272 (53,945-65,588) [0.9%]	27.3 (24.7-28.2)	0.4 (0.4-1.1)	958,202 (877,140-998,032) [1.4%]	68,626 (68,196-101,591) [0.9%]	856,611 (808,943-929,406) [1.4%]

	World Bank Region	Cervical cancer deaths from 2020-2070 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2070 if S3 [% of all 78 LMICs]	ASR mortality (S0), 2120	ASR mortality (S3), 2120	Cervical cancer deaths from 2020-2120 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2120 if S3 [% of all 78 LMICs]	Cervical cancer deaths averted from 2020-2120 if S3 [% of all 78 LMICs]
<b>Central African Republic</b>	Sub-Saharan Africa	27,070 (26,998-30,368) [0.1%]	7,129 (6,659-7,570) [0.1%]	17.6 (17.2-19.8)	0.3 (0.3-0.7)	109,902 (106,377-124,069) [0.2%]	9,014 (8,577-11,776) [0.1%]	101,325 (94,600-115,054) [0.2%]
<b>Chad</b>	Sub-Saharan Africa	86,109 (85,524-94,240) [0.4%]	18,830 (17,403-22,184) [0.3%]	17.8 (17.1-19.5)	0.3 (0.2-0.7)	392,526 (378,550-430,463) [0.6%]	24,194 (22,739-35,699) [0.3%]	369,787 (342,850-406,268) [0.6%]
<b>Comoros</b>	Sub-Saharan Africa	12,876 (12,470-13,050) [0.1%]	3,318 (3,194-3,731) [0.1%]	46.2 (43.9-46.5)	0.6 (0.6-1.8)	44,031 (42,005-44,401) [0.1%]	3,980 (3,791-5,268) [0.1%]	40,051 (36,737-40,609) [0.1%]
<b>Côte d'Ivoire</b>	Sub-Saharan Africa	209,819 (183,528-212,038) [1.0%]	46,059 (42,040-64,356) [0.7%]	28.5 (26.0-30.2)	0.4 (0.3-1.2)	970,490 (875,651-1,013,667) [1.4%]	59,499 (54,841-103,673) [0.8%]	866,817 (820,810-954,168) [1.4%]
<b>Democratic Republic of the Congo</b>	Sub-Saharan Africa	691,033 (663,524-732,289) [3.3%]	172,719 (162,047-196,315) [2.7%]	23.4 (22.9-25.4)	0.4 (0.3-1.0)	3,398,306 (3,364,226-3,729,062) [4.8%]	231,383 (222,859-338,080) [3.0%]	3,141,366 (3,060,226-3,497,679) [5.0%]
<b>Djibouti</b>	Middle East & North Africa	4,107 (3,259-4,390) [0.0%]	1,179 (1,125-1,212) [0.0%]	11.4 (9.0-12.3)	0.1 (0.1-0.4)	10,025 (7,702-10,816) [0.0%]	1,318 (1,234-1,493) [0.0%]	8,791 (6,209-9,497) [0.0%]
<b>El Salvador</b>	Latin America & Caribbean	27,609 (22,866-38,864) [0.1%]	12,349 (11,477-18,238) [0.2%]	10.4 (8.5-14.0)	0.2 (0.2-0.8)	60,441 (51,170-87,850) [0.1%]	14,639 (14,271-26,420) [0.2%]	46,170 (36,530-61,430) [0.1%]
<b>Eritrea</b>	Sub-Saharan Africa	23,448 (22,986-25,331) [0.1%]	5,719 (5,447-6,576) [0.1%]	12.5 (12.2-13.5)	0.1 (0.1-0.5)	85,468 (81,371-92,845) [0.1%]	6,985 (6,464-9,773) [0.1%]	79,003 (71,597-85,860) [0.1%]
<b>eSwatini (formerly Swaziland)</b>	Sub-Saharan Africa	31,816 (25,287-32,020) [0.2%]	8,644 (8,201-10,418) [0.1%]	70.2 (55.0-72.0)	1.1 (1.0-3.5)	103,393 (79,965-111,885) [0.1%]	10,999 (10,129-17,687) [0.1%]	92,394 (69,835-94,198) [0.1%]
<b>Ethiopia</b>	Sub-Saharan Africa	695,863 (695,265-703,116) [3.4%]	172,038 (161,025-196,857) [2.7%]	17.2 (17.0-17.3)	0.3 (0.2-0.7)	2,310,075 (2,228,891-2,326,000) [3.3%]	210,050 (197,131-283,231) [2.7%]	2,100,024 (1,945,659-2,128,868) [3.4%]
<b>Georgia</b>	Europe & Central Asia	7,008 (4,088-8,200) [0.0%]	4,241 (2,859-4,246) [0.1%]	5.3 (3.0-6.0)	0.1 (0.1-0.2)	12,154 (7,123-14,294) [0.0%]	4,540 (3,109-4,753) [0.1%]	7,401 (4,013-9,753) [0.0%]
<b>Ghana</b>	Sub-Saharan Africa	276,643 (272,236-329,592) [1.3%]	76,700 (73,390-108,290) [1.2%]	27.4 (27.1-31.9)	0.4 (0.4-1.3)	996,600 (984,342-1,142,531) [1.4%]	93,408 (88,997-152,284) [1.2%]	907,602 (890,934-990,246) [1.4%]
<b>Guinea</b>	Sub-Saharan Africa	195,421 (189,854-211,564) [0.9%]	46,178 (43,082-57,884) [0.7%]	43.0 (42.0-46.9)	0.5 (0.4-1.8)	847,684 (831,784-927,948) [1.2%]	59,504 (54,979-95,725) [0.8%]	776,804 (751,959-868,444) [1.2%]
<b>Guinea-Bissau</b>	Sub-Saharan Africa	19,410 (18,560-21,716) [0.1%]	4,696 (4,266-5,924) [0.1%]	29.6 (29.1-34.5)	0.4 (0.4-1.2)	74,894 (73,346-86,544) [0.1%]	5,814 (5,345-8,931) [0.1%]	68,001 (65,962-80,729) [0.1%]

	<b>World Bank Region</b>	<b>Cervical cancer deaths from 2020-2070 for <i>status quo</i> (S0) [% of all 78 LMICs]</b>	<b>Cervical cancer deaths from 2020-2070 if S3 [% of all 78 LMICs]</b>	<b>ASR mortality (S0), 2120</b>	<b>ASR mortality (S3), 2120</b>	<b>Cervical cancer deaths from 2020-2120 for <i>status quo</i> (S0) [% of all 78 LMICs]</b>	<b>Cervical cancer deaths from 2020-2120 if S3 [% of all 78 LMICs]</b>	<b>Cervical cancer deaths averted from 2020-2120 if S3 [% of all 78 LMICs]</b>
<b>Haiti</b>	Latin America & Caribbean	58,864 (49,110-60,075) [0.3%]	15,680 (15,472-20,056) [0.2%]	15.8 (13.0-16.1)	0.2 (0.2-0.8)	146,599 (123,615-150,185) [0.2%]	17,853 (17,725-27,864) [0.2%]	128,873 (95,751-132,332) [0.2%]
<b>Honduras</b>	Latin America & Caribbean	54,686 (37,832-56,040) [0.3%]	17,784 (14,836-20,657) [0.3%]	14.3 (9.9-14.7)	0.3 (0.2-0.7)	131,961 (92,325-136,569) [0.2%]	20,533 (17,933-28,319) [0.3%]	103,641 (74,392-116,035) [0.2%]
<b>India</b>	South Asia	5,266,624 (5,085,011-5,774,738) [25.4%]	1,988,647 (1,919,681-2,208,510) [31.3%]	10.5 (10.1-11.6)	0.1 (0.1-0.3)	12,085,921 (11,665,752-13,182,465) [17.2%]	2,274,947 (2,162,488-2,692,731) [29.8%]	9,923,432 (9,390,805-10,489,733) [15.8%]
<b>Indonesia</b>	East Asia & Pacific	1,787,799 (1,575,604-1,809,510) [8.6%]	609,212 (601,589-720,150) [9.6%]	17.8 (15.5-18.0)	0.3 (0.3-0.6)	3,950,456 (3,554,242-4,075,877) [5.6%]	679,678 (669,437-852,139) [8.9%]	3,098,316 (2,874,564-3,406,439) [4.9%]
<b>Kenya</b>	Sub-Saharan Africa	541,927 (508,803-611,583) [2.6%]	144,796 (141,054-182,316) [2.3%]	27.7 (26.0-31.1)	0.4 (0.3-1.3)	1,942,881 (1,830,197-2,152,166) [2.8%]	181,815 (175,246-275,505) [2.4%]	1,767,634 (1,648,381-1,876,661) [2.8%]
<b>Korea Democratic People's Republic</b>	East Asia & Pacific	55,198 (32,835-70,242) [0.3%]	21,859 (19,708-30,057) [0.3%]	6.0 (3.5-7.8)	0.1 (0.1-0.3)	105,158 (62,512-133,847) [0.1%]	23,356 (21,327-34,430) [0.3%]	81,802 (41,184-99,416) [0.1%]
<b>Kyrgyz Republic</b>	Europe & Central Asia	24,972 (23,345-26,761) [0.1%]	11,253 (10,403-11,386) [0.2%]	11.3 (10.7-12.1)	0.3 (0.2-0.5)	60,243 (55,670-64,809) [0.1%]	12,777 (11,930-13,852) [0.2%]	48,312 (41,817-52,032) [0.1%]
<b>Lao People's Democratic Republic</b>	East Asia & Pacific	20,446 (18,384-21,975) [0.1%]	6,896 (6,346-8,036) [0.1%]	7.9 (7.1-8.6)	0.1 (0.1-0.3)	50,139 (44,797-52,280) [0.1%]	8,057 (7,265-10,141) [0.1%]	42,082 (37,532-42,139) [0.1%]
<b>Lesotho</b>	Sub-Saharan Africa	33,119 (28,029-33,444) [0.2%]	9,401 (8,953-11,219) [0.1%]	49.0 (40.8-49.6)	0.7 (0.7-2.4)	107,230 (88,457-113,781) [0.2%]	11,672 (10,832-18,067) [0.2%]	95,557 (77,624-95,714) [0.2%]
<b>Liberia</b>	Sub-Saharan Africa	60,169 (57,032-65,191) [0.3%]	14,210 (13,387-18,542) [0.2%]	35.3 (33.9-38.9)	0.4 (0.3-1.5)	256,136 (248,772-285,721) [0.4%]	18,126 (17,011-29,942) [0.2%]	231,761 (226,194-267,595) [0.4%]
<b>Madagascar</b>	Sub-Saharan Africa	444,353 (436,439-465,373) [2.1%]	112,239 (109,906-137,900) [1.8%]	44.9 (44.1-47.0)	0.6 (0.6-2.0)	1,801,424 (1,771,388-1,889,446) [2.6%]	143,550 (140,788-223,601) [1.9%]	1,660,636 (1,627,838-1,665,844) [2.7%]
<b>Malawi</b>	Sub-Saharan Africa	464,435 (464,114-521,662) [2.2%]	110,302 (109,682-117,351) [1.7%]	61.4 (60.8-68.9)	0.9 (0.9-2.5)	1,841,133 (1,790,009-2,060,011) [2.6%]	140,633 (137,481-180,496) [1.8%]	1,700,499 (1,609,513-1,922,530) [2.7%]
<b>Mali</b>	Sub-Saharan Africa	251,443 (239,009-265,808) [1.2%]	55,998 (52,017-66,545) [0.9%]	39.4 (38.6-43.1)	0.5 (0.4-1.6)	1,179,879 (1,156,068-1,289,124) [1.7%]	73,309 (66,885-109,442) [1.0%]	1,089,182 (1,070,437-1,215,815) [1.7%]
<b>Mauritania</b>	Sub-Saharan Africa	46,394 (35,785-49,859) [0.2%]	11,612 (10,365-15,879) [0.2%]	29.7 (22.9-31.7)	0.4 (0.4-1.4)	178,287 (137,447-190,908) [0.3%]	14,313 (13,078-24,057) [0.2%]	163,974 (124,368-166,851) [0.3%]
<b>Moldova</b>	Europe & Central Asia	15,323 (12,549-17,601) [0.1%]	8,897 (8,346-9,143) [0.1%]	11.0 (8.9-12.5)	0.4 (0.3-0.6)	23,793 (19,664-27,497) [0.0%]	9,475 (8,824-10,044) [0.1%]	13,749 (10,840-18,021) [0.0%]

	World Bank Region	Cervical cancer deaths from 2020-2070 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2070 if S3 [% of all 78 LMICs]	ASR mortality (S0), 2120	ASR mortality (S3), 2120	Cervical cancer deaths from 2020-2120 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2120 if S3 [% of all 78 LMICs]	Cervical cancer deaths averted from 2020-2120 if S3 [% of all 78 LMICs]
<b>Mongolia</b>	East Asia & Pacific	20,804 (12,868-20,930) [0.1%]	7,423 (7,010-8,227) [0.1%]	17.2 (10.6-17.4)	0.4 (0.2-0.6)	49,773 (31,192-50,689) [0.1%]	8,451 (8,054-10,049) [0.1%]	39,723 (23,138-42,237) [0.1%]
<b>Morocco</b>	Middle East & North Africa	221,333 (207,877-250,832) [1.1%]	82,604 (76,012-93,373) [1.3%]	13.6 (13.1-15.4)	0.2 (0.1-0.6)	515,424 (474,767-585,679) [0.7%]	94,349 (87,511-121,417) [1.2%]	427,913 (353,350-491,329) [0.7%]
<b>Mozambique</b>	Sub-Saharan Africa	455,659 (420,326-458,117) [2.2%]	103,625 (101,922-117,128) [1.6%]	40.4 (37.9-40.7)	0.6 (0.6-1.7)	2,011,266 (1,920,943-2,028,723) [2.9%]	136,219 (135,068-208,680) [1.8%]	1,875,047 (1,712,263-1,893,655) [3.0%]
<b>Myanmar</b>	East Asia & Pacific	274,412 (230,305-293,721) [1.3%]	105,194 (95,272-111,995) [1.7%]	14.1 (11.8-15.3)	0.3 (0.2-0.5)	565,737 (474,618-602,201) [0.8%]	113,504 (104,716-129,284) [1.5%]	452,233 (369,901-472,916) [0.7%]
<b>Nepal</b>	South Asia	170,600 (167,646-189,845) [0.8%]	59,057 (56,275-61,665) [0.9%]	15.4 (14.7-16.6)	0.3 (0.2-0.4)	324,821 (318,855-367,441) [0.5%]	63,583 (61,459-66,802) [0.8%]	258,018 (257,396-303,857) [0.4%]
<b>Nicaragua</b>	Latin America & Caribbean	39,834 (39,699-43,189) [0.2%]	13,918 (13,691-16,692) [0.2%]	15.4 (15.3-16.7)	0.3 (0.3-0.8)	89,064 (88,690-96,952) [0.1%]	16,392 (15,434-22,743) [0.2%]	73,255 (66,320-80,559) [0.1%]
<b>Niger</b>	Sub-Saharan Africa	69,304 (67,710-77,472) [0.3%]	14,629 (13,531-16,856) [0.2%]	8.8 (8.4-9.9)	0.1 (0.1-0.3)	454,124 (433,031-508,346) [0.6%]	20,951 (17,825-33,033) [0.3%]	436,299 (399,998-487,394) [0.7%]
<b>Nigeria</b>	Sub-Saharan Africa	1,482,189 (1,404,478-1,587,027) [7.1%]	351,700 (335,537-458,062) [5.5%]	24.6 (23.4-25.3)	0.3 (0.3-1.0)	6,967,769 (6,615,831-7,122,422) [9.9%]	455,708 (429,530-710,711) [6.0%]	6,411,711 (6,160,122-6,538,238) [10.2%]
<b>Pakistan</b>	South Asia	402,742 (395,074-419,051) [1.9%]	129,980 (120,887-130,025) [2.0%]	5.6 (5.5-5.8)	0.1 (0.1-0.2)	1,096,015 (1,087,028-1,166,034) [1.6%]	149,905 (134,586-156,617) [2.0%]	961,428 (930,411-1,016,128) [1.5%]
<b>Papua New Guinea</b>	East Asia & Pacific	58,804 (53,110-60,232) [0.3%]	17,267 (15,787-19,068) [0.3%]	19.4 (17.5-20.2)	0.4 (0.3-0.8)	167,856 (152,308-175,166) [0.2%]	19,717 (18,727-25,629) [0.3%]	148,139 (133,580-149,537) [0.2%]
<b>Philippines</b>	East Asia & Pacific	377,925 (320,269-449,472) [1.8%]	140,511 (128,322-166,619) [2.2%]	9.5 (8.0-11.4)	0.1 (0.1-0.4)	1,009,180 (855,800-1,186,758) [1.4%]	163,508 (147,331-213,497) [2.1%]	845,671 (708,468-973,261) [1.3%]
<b>Republic of Yemen</b>	Middle East & North Africa	15,712 (12,657-17,908) [0.1%]	4,086 (3,819-4,401) [0.1%]	1.5 (1.2-1.7)	0.0 (0.0-0.1)	45,917 (36,304-52,548) [0.1%]	5,311 (4,405-5,470) [0.1%]	41,511 (30,834-47,236) [0.1%]
<b>Republic of the Congo</b>	Sub-Saharan Africa	30,080 (26,437-33,330) [0.1%]	8,498 (8,246-10,711) [0.1%]	15.6 (13.7-17.1)	0.2 (0.1-0.7)	142,931 (125,538-153,277) [0.2%]	10,941 (10,720-17,689) [0.1%]	132,211 (114,596-135,587) [0.2%]
<b>Rwanda</b>	Sub-Saharan Africa	142,063 (141,574-142,826) [0.7%]	35,882 (34,334-43,783) [0.6%]	29.3 (29.2-29.5)	0.5 (0.4-1.2)	472,953 (456,403-473,792) [0.7%]	43,855 (41,985-62,287) [0.6%]	429,936 (394,116-430,968) [0.7%]
<b>Senegal</b>	Sub-Saharan Africa	211,838 (211,704-219,875) [1.0%]	50,448 (49,180-66,917) [0.8%]	34.9 (34.8-35.7)	0.4 (0.3-1.5)	918,513 (912,839-921,710) [1.3%]	64,889 (62,150-106,215) [0.8%]	850,688 (815,495-853,624) [1.4%]
<b>Sierra Leone</b>	Sub-Saharan Africa	29,024 (27,669-31,659) [0.1%]	6,943 (6,418-8,630) [0.1%]	12.7 (12.4-14.4)	0.1 (0.1-0.5)	99,090 (95,769-110,002) [0.1%]	8,280 (7,395-12,389) [0.1%]	88,373 (86,701-101,721) [0.1%]

	World Bank Region	Cervical cancer deaths from 2020-2070 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2070 if S3 [% of all 78 LMICs]	ASR mortality (S0), 2120	ASR mortality (S3), 2120	Cervical cancer deaths from 2020-2120 for <i>status quo</i> (S0) [% of all 78 LMICs]	Cervical cancer deaths from 2020-2120 if S3 [% of all 78 LMICs]	Cervical cancer deaths averted from 2020-2120 if S3 [% of all 78 LMICs]
<b>Solomon Islands</b>	East Asia & Pacific	3,099 (3,001-3,505) [0.0%]	939 (845-942) [0.0%]	14.2 (13.6-15.9)	0.3 (0.2-0.5)	8,871 (8,733-10,198) [0.0%]	1,066 (993-1,186) [0.0%]	7,740 (7,685-9,131) [0.0%]
<b>Somalia</b>	Sub-Saharan Africa	111,562 (109,348-119,468) [0.5%]	24,854 (23,343-28,336) [0.4%]	22.3 (21.4-23.9)	0.3 (0.3-0.9)	556,139 (534,492-595,960) [0.8%]	32,367 (31,399-48,041) [0.4%]	524,739 (486,450-563,592) [0.8%]
<b>South Sudan</b>	Sub-Saharan Africa	110,044 (106,843-117,517) [0.5%]	26,881 (25,257-30,895) [0.4%]	25.1 (24.3-26.8)	0.4 (0.3-1.0)	431,844 (417,413-461,500) [0.6%]	33,210 (31,784-47,377) [0.4%]	400,059 (370,035-428,289) [0.6%]
<b>Sri Lanka</b>	South Asia	48,947 (39,616-58,754) [0.2%]	20,421 (19,637-26,998) [0.3%]	5.2 (4.3-6.4)	0.1 (0.1-0.2)	96,250 (77,179-115,137) [0.1%]	23,124 (22,111-32,628) [0.3%]	73,125 (55,068-82,509) [0.1%]
<b>Sudan</b>	Sub-Saharan Africa	111,782 (90,841-113,439) [0.5%]	28,729 (25,665-34,243) [0.5%]	7.6 (6.2-7.7)	0.1 (0.1-0.3)	429,962 (355,649-439,212) [0.6%]	35,861 (30,384-50,196) [0.5%]	379,766 (325,264-403,351) [0.6%]
<b>Syrian Arab Republic</b>	Middle East & North Africa	23,943 (23,889-26,036) [0.1%]	7,751 (7,270-9,245) [0.1%]	2.6 (2.6-2.9)	0.0 (0.0-0.1)	71,551 (70,629-75,744) [0.1%]	9,518 (9,277-14,642) [0.1%]	61,351 (56,909-66,225) [0.1%]
<b>São Tomé and Príncipe</b>	Sub-Saharan Africa	895 (398-1,041) [0.0%]	232 (193-258) [0.0%]	12.4 (5.6-14.6)	0.1 (0.1-0.7)	3,053 (1,347-3,527) [0.0%]	269 (236-400) [0.0%]	2,653 (1,110-3,258) [0.0%]
<b>Tajikistan</b>	Europe & Central Asia	11,335 (9,986-11,781) [0.1%]	4,133 (4,056-4,304) [0.1%]	3.3 (3.0-3.5)	0.1 (0.0-0.1)	30,888 (26,946-32,223) [0.0%]	4,885 (4,587-5,329) [0.1%]	26,003 (21,616-27,635) [0.0%]
<b>Tanzania</b>	Sub-Saharan Africa	1,106,067 (1,084,668-1,216,092) [5.3%]	275,692 (264,989-351,389) [4.3%]	51.3 (50.4-55.7)	0.7 (0.6-2.2)	5,477,199 (5,394,107-5,871,072) [7.8%]	373,746 (351,220-601,897) [4.9%]	5,125,978 (5,020,360-5,269,174) [8.2%]
<b>The Gambia</b>	Sub-Saharan Africa	18,270 (17,890-19,944) [0.1%]	4,096 (4,059-4,773) [0.1%]	24.6 (23.6-26.4)	0.4 (0.4-1.1)	70,512 (68,149-76,088) [0.1%]	5,115 (5,082-7,576) [0.1%]	63,067 (62,935-70,972) [0.1%]
<b>Timor-Leste</b>	East Asia & Pacific	2,941 (2,767-3,494) [0.0%]	894 (835-1,005) [0.0%]	7.4 (7.0-8.7)	0.2 (0.1-0.3)	11,677 (10,987-13,166) [0.0%]	1,124 (1,060-1,379) [0.0%]	10,617 (9,863-11,786) [0.0%]
<b>Togo</b>	Sub-Saharan Africa	56,590 (55,567-58,912) [0.3%]	13,528 (12,927-18,238) [0.2%]	22.2 (21.8-22.9)	0.3 (0.3-1.0)	218,911 (214,829-226,979) [0.3%]	16,584 (16,053-27,659) [0.2%]	199,320 (198,775-202,327) [0.3%]
<b>Tunisia</b>	Middle East & North Africa	16,016 (15,622-18,633) [0.1%]	6,537 (5,286-7,334) [0.1%]	3.0 (3.0-3.4)	0.0 (0.0-0.1)	35,073 (33,552-40,969) [0.1%]	7,410 (5,955-9,125) [0.1%]	29,117 (24,427-33,558) [0.0%]
<b>Uganda</b>	Sub-Saharan Africa	764,126 (741,681-812,003) [3.7%]	169,360 (168,745-196,326) [2.7%]	48.3 (46.4-50.8)	0.7 (0.7-2.1)	3,663,496 (3,501,180-3,834,152) [5.2%]	230,244 (228,182-357,931) [3.0%]	3,305,564 (3,270,936-3,605,970) [5.3%]
<b>Ukraine</b>	Europe & Central Asia	109,727 (103,832-118,041) [0.5%]	68,116 (65,900-68,790) [1.1%]	7.8 (7.3-8.6)	0.2 (0.2-0.4)	183,137 (173,623-196,584) [0.3%]	71,678 (69,360-74,892) [0.9%]	113,776 (101,945-121,691) [0.2%]

	<b>World Bank Region</b>	<b>Cervical cancer deaths from 2020-2070 for <i>status quo</i> (S0) [% of all 78 LMICs]</b>	<b>Cervical cancer deaths from 2020-2070 if S3 [% of all 78 LMICs]</b>	<b>ASR mortality (S0), 2120</b>	<b>ASR mortality (S3), 2120</b>	<b>Cervical cancer deaths from 2020-2120 for <i>status quo</i> (S0) [% of all 78 LMICs]</b>	<b>Cervical cancer deaths from 2020-2120 if S3 [% of all 78 LMICs]</b>	<b>Cervical cancer deaths averted from 2020-2120 if S3 [% of all 78 LMICs]</b>
<b>Uzbekistan</b>	Europe & Central Asia	72,956 (68,931-74,641) [0.4%]	32,778 (30,755-33,397) [0.5%]	5.7 (5.6-5.9)	0.1 (0.1-0.2)	157,426 (144,906-161,730) [0.2%]	36,513 (33,537-38,522) [0.5%]	123,889 (106,383-125,216) [0.2%]
<b>Vanuatu</b>	East Asia & Pacific	1,068 (985-1,085) [0.0%]	315 (306-323) [0.0%]	9.8 (8.9-10.0)	0.1 (0.1-0.3)	2,839 (2,672-2,942) [0.0%]	358 (330-376) [0.0%]	2,463 (2,313-2,611) [0.0%]
<b>Vietnam</b>	East Asia & Pacific	218,907 (192,086-225,119) [1.1%]	83,121 (82,410-97,094) [1.3%]	5.3 (4.5-5.3)	0.1 (0.1-0.2)	449,656 (400,215-467,478) [0.6%]	92,759 (92,580-116,854) [1.2%]	332,801 (307,635-374,719) [0.5%]
<b>West Bank and Gaza</b>	Middle East & North Africa	3,546 (3,367-4,128) [0.0%]	981 (934-1,309) [0.0%]	1.8 (1.7-2.1)	0.0 (0.0-0.1)	15,278 (12,404-16,753) [0.0%]	1,403 (1,191-2,689) [0.0%]	12,588 (11,213-15,350) [0.0%]
<b>Zambia</b>	Sub-Saharan Africa	334,382 (319,785-397,971) [1.6%]	86,305 (82,316-116,457) [1.4%]	54.1 (51.6-63.7)	0.8 (0.7-2.7)	1,724,389 (1,644,539-2,020,711) [2.5%]	120,722 (113,725-212,577) [1.6%]	1,603,667 (1,530,813-1,808,134) [2.6%]
<b>Zimbabwe</b>	Sub-Saharan Africa	331,836 (284,840-354,376) [1.6%]	90,308 (84,218-110,294) [1.4%]	56.0 (48.1-59.7)	0.8 (0.7-2.6)	1,231,286 (1,056,498-1,317,225) [1.8%]	116,111 (109,040-177,738) [1.5%]	1,115,175 (947,458-1,139,487) [1.8%]

Caution should be applied in interpreting comparative differences between the numbers in this table since all values represent median and range across models and may therefore represent different models as medians for each entry in the table.

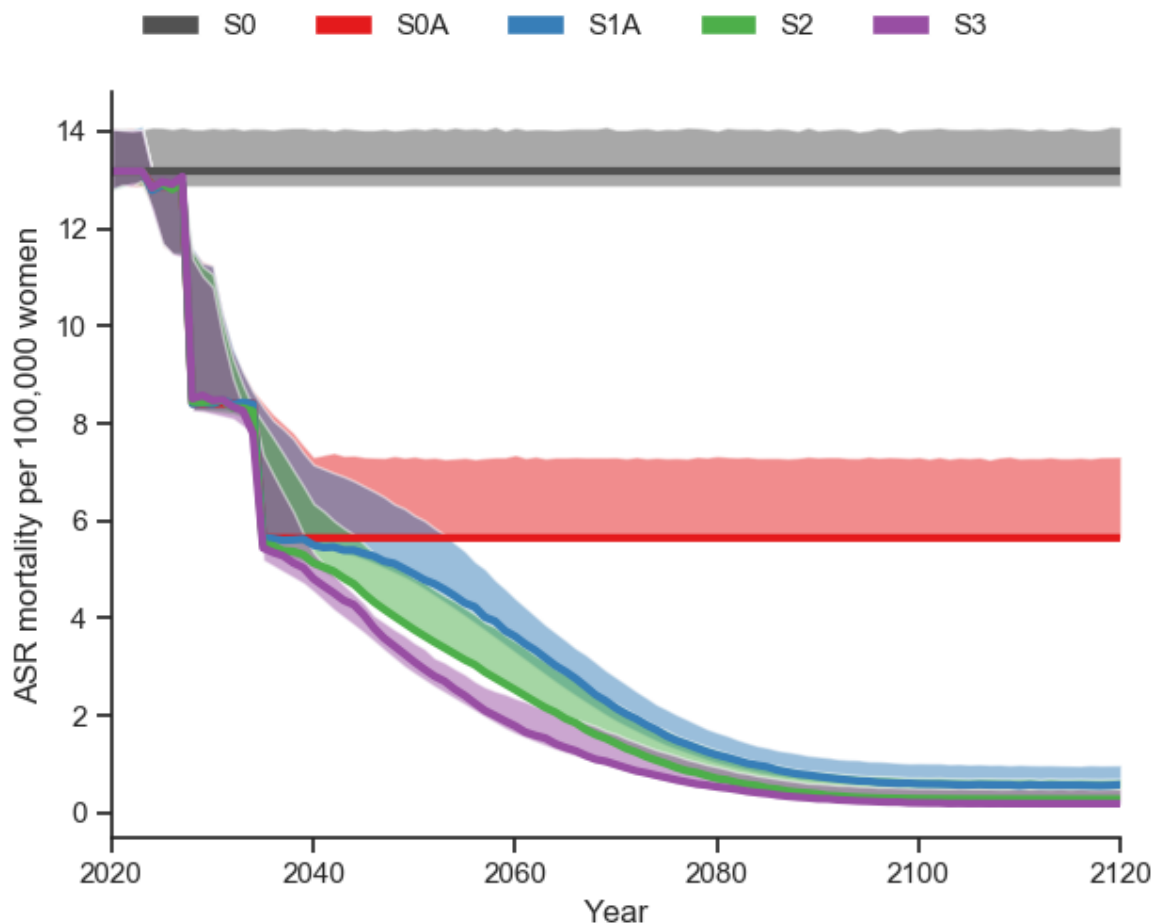
## Section 6. Explanatory and sensitivity analysis results

*Figure AR3* shows a range of explanatory results. *Figure AR3(a)* shows the relative contribution of cancer treatment scale-up, female-only vaccination, a single screen at age 35, and a second screen at age 45, on the overall mortality outcomes over time for ‘S3’, the triple-intervention strategy. *Figure AR3(b)* and *AR3(c)* show the contribution of cancer treatment to the findings for S2 (i.e. vaccination, once-lifetime screening and cancer treatment) and S3 (i.e. vaccination, twice-lifetime screening and cancer treatment). *Figure AR3(d)* shows the relative benefits of the supplementary strategies for vaccination. *Figure AR3(e)* shows the counterfactual scenario in which girls-only vaccination was scaled-up with cancer treatment but without cervical screening, and *Figure AR3(f)* and *(g)* show the same counterfactual for the supplementary vaccine strategies. These explanatory results demonstrate that the main benefits to 2030 are via cancer treatment scale-up, and that screening adds substantial mortality benefit over that conferred by vaccination and cancer treatment scaleup from the period 2030 to 2070-2080.

*Figure AR4* shows that the choice of standard population is an important driver for rate findings, and hence emphasises the importance of using the World Female Population 2015 (WFP2015) for future comparability of any other results with our findings. For example, for the ‘triple elimination strategy’ (S3), the base case assumption yielded a rate of 0.2 (0.2-0.5) per 100,000 women by 2120 across models, but this varied from 0.2 (0.1-0.4) (Segi Population) to 0.2 (0.2-0.6) (World Female Population 2030). *Figure AR5* shows that the uncertainty in the projections of population size and age-structure projections for the 78 LMICs over the course of a century (which include some of the world’s most populous nations such as India, Nigeria and other countries in Sub-Saharan Africa,) dominates differences in the CCEMC models with respect to structure, herd immunity predictions, or parameterisation in terms of the impact on our final estimates of deaths averted. For example, in our base case estimates for the triple elimination strategy (S3), which is based on UN population projections with median fertility variant, the cumulative number of deaths averted compared to S0 over the period 2020-2120 was 62.6M with a range from 62.1-62.8M. However, the variation in the estimates of deaths averted when using the ‘low’ and ‘high’ UN fertility variants applied to model results was much higher than that generated by differences between models; for the ‘low’ variant the cumulative estimate was 53.7M (53.6-54.2)M and for the ‘high’ variant the cumulative estimate was 72.6M (71.7-72.8)M. Thus, for deaths averted, differences between individual model estimates were much smaller than the unavoidable uncertainties in the assumptions about future population projections over 100-year time horizon.

**Figure AR3. Explanatory analyses of the combination of different interventions over time: Age-standardised mortality rates across all 78 LMICs**

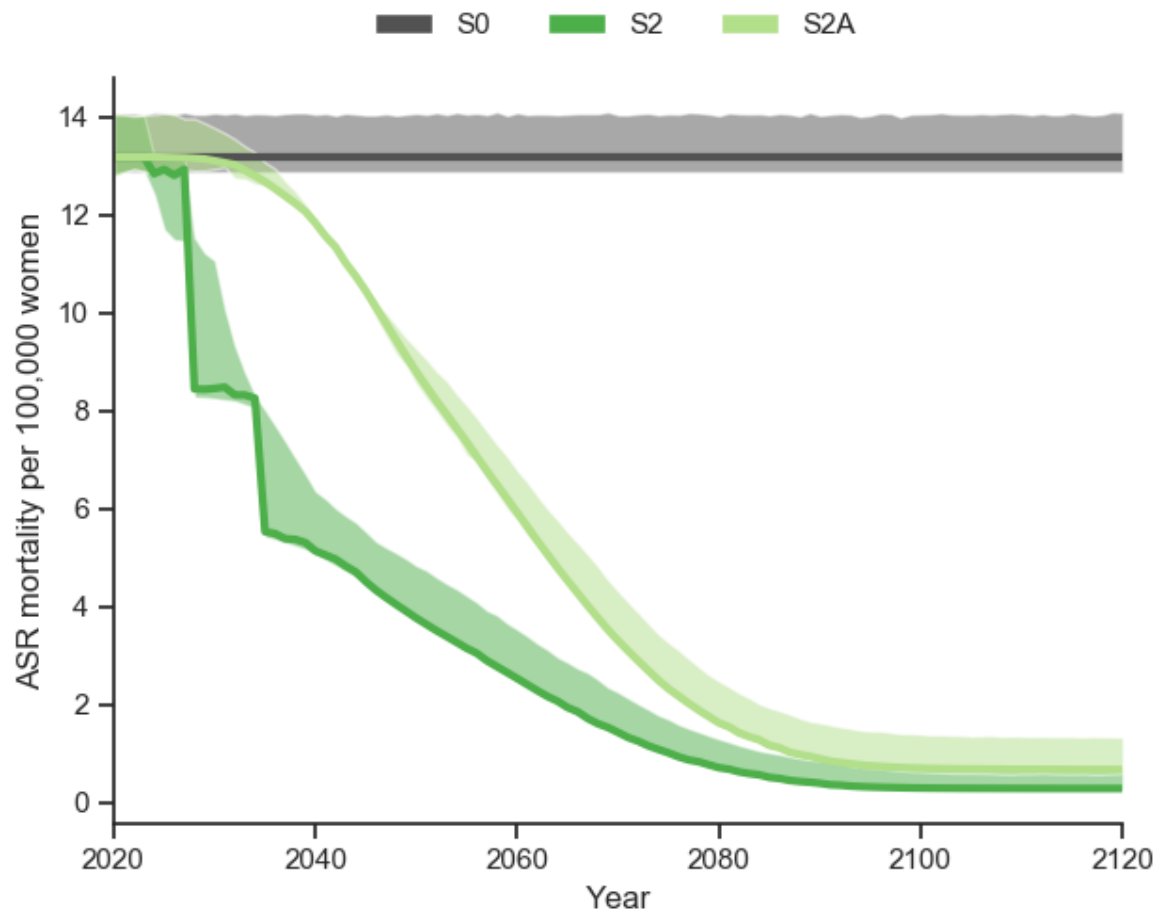
(a) Explanatory 'build' from status quo to add cancer treatment scaleup (S0A), then adding female-only vaccination (S1A), then adding a screen at 35 years of age (S2) and then adding a second screen at 45 years of age (S3).



The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

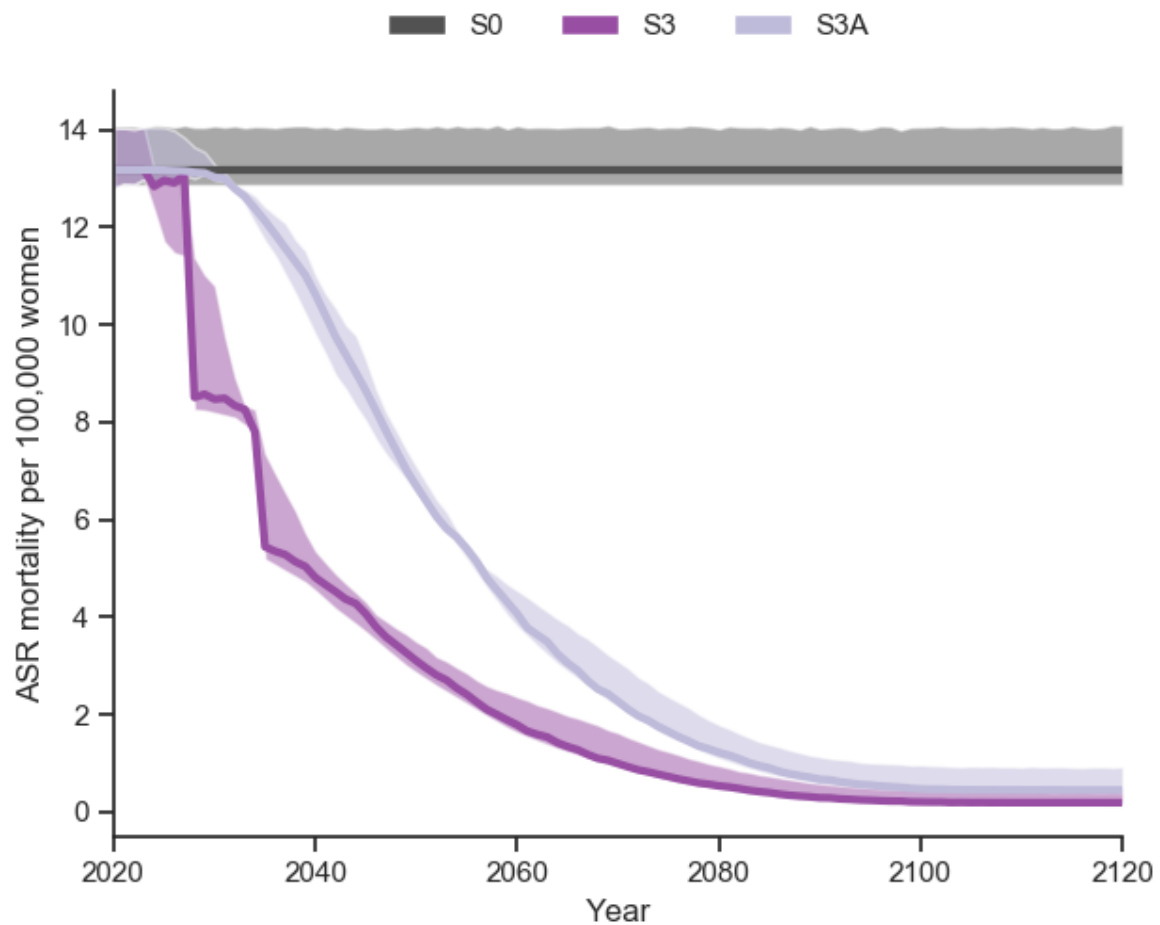
(b) Explanatory ‘build’ from status quo to show Scenario S2 (vaccination, once-lifetime screening, and cancer treatment scale-up, alongside explanatory scenario S2A (same as S2 but without cancer treatment scaleup).



The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

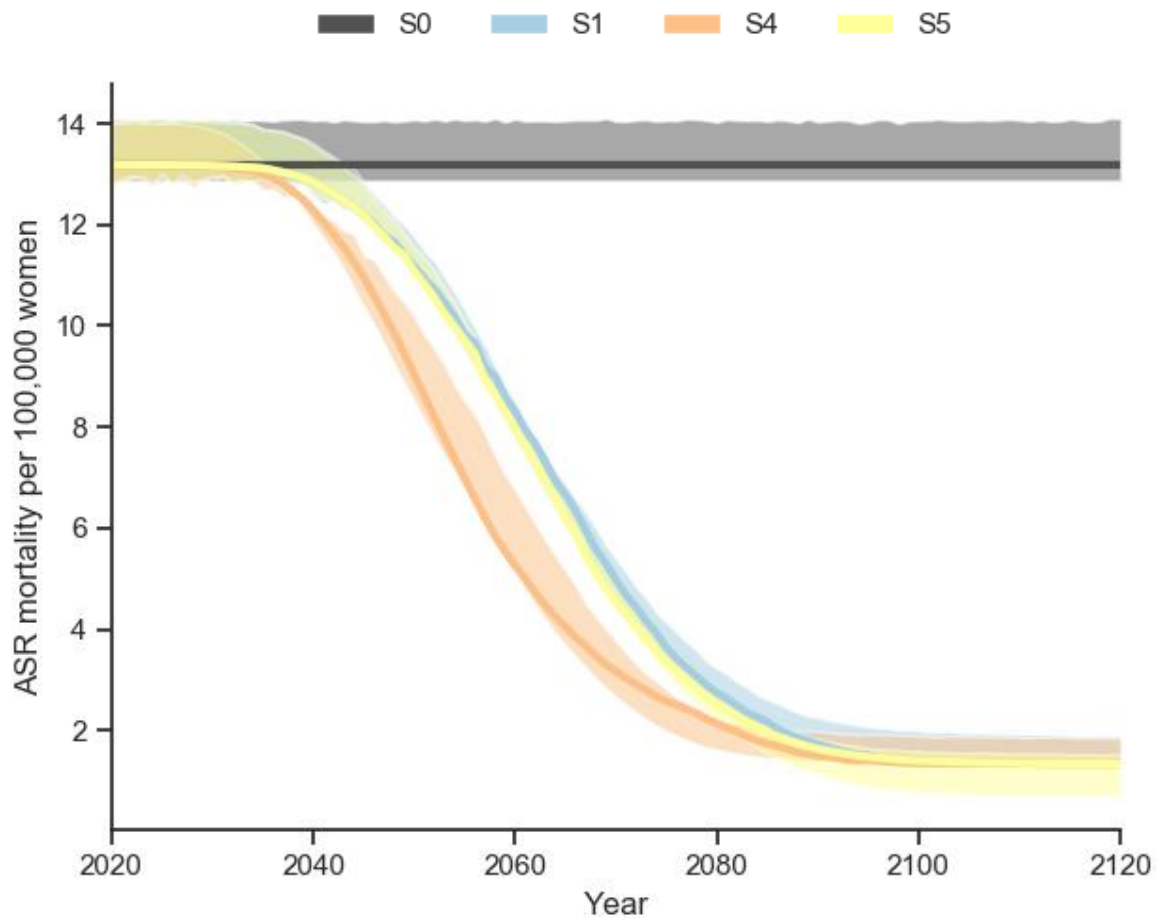
(c) Explanatory 'build' from status quo to show Scenario S3 (vaccination, twice-lifetime screening, and cancer treatment scale-up, alongside explanatory scenario S3A (same as S3 but without cancer treatment scaleup).



The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

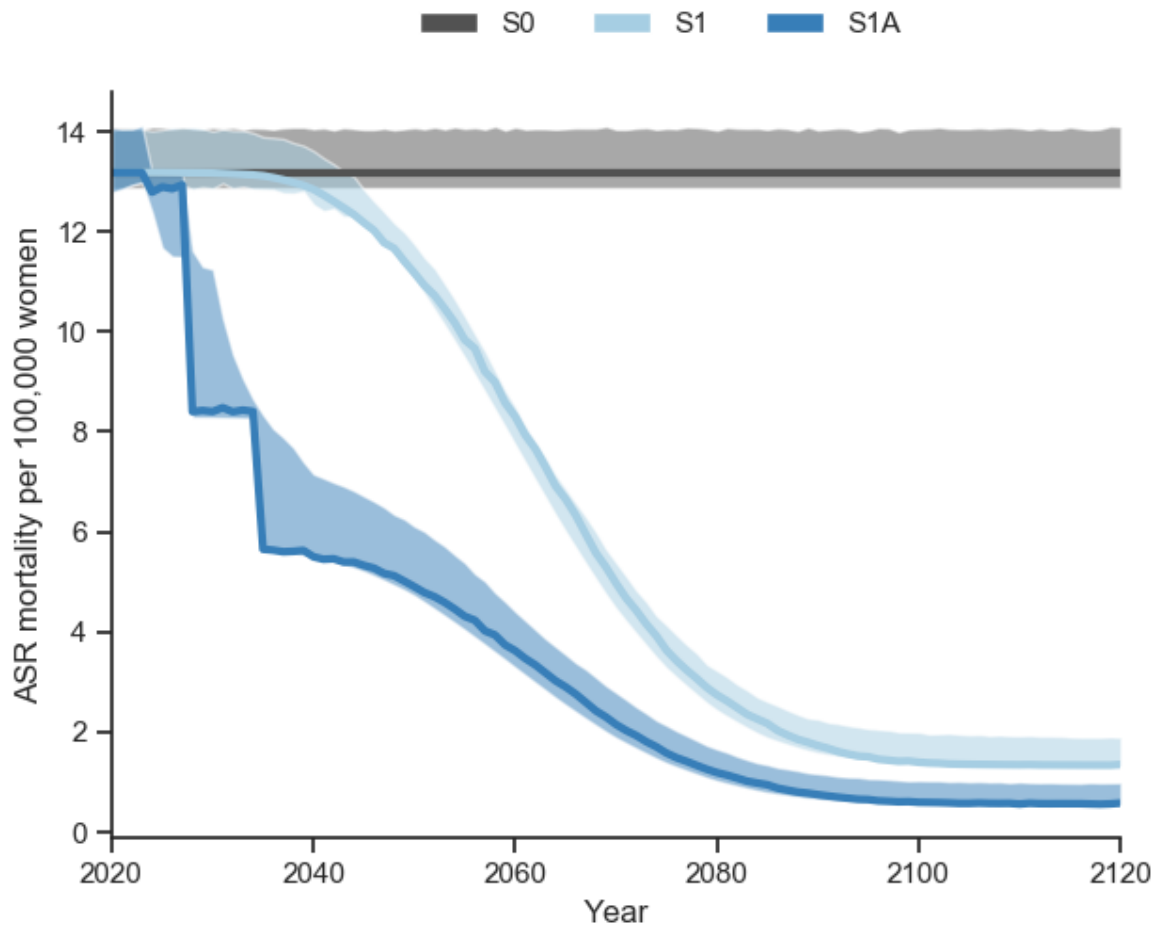
(d) Explanatory ‘build’ from status quo (S0) to show vaccination-only strategies S1, Supplementary S4 and Supplementary S5.



The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

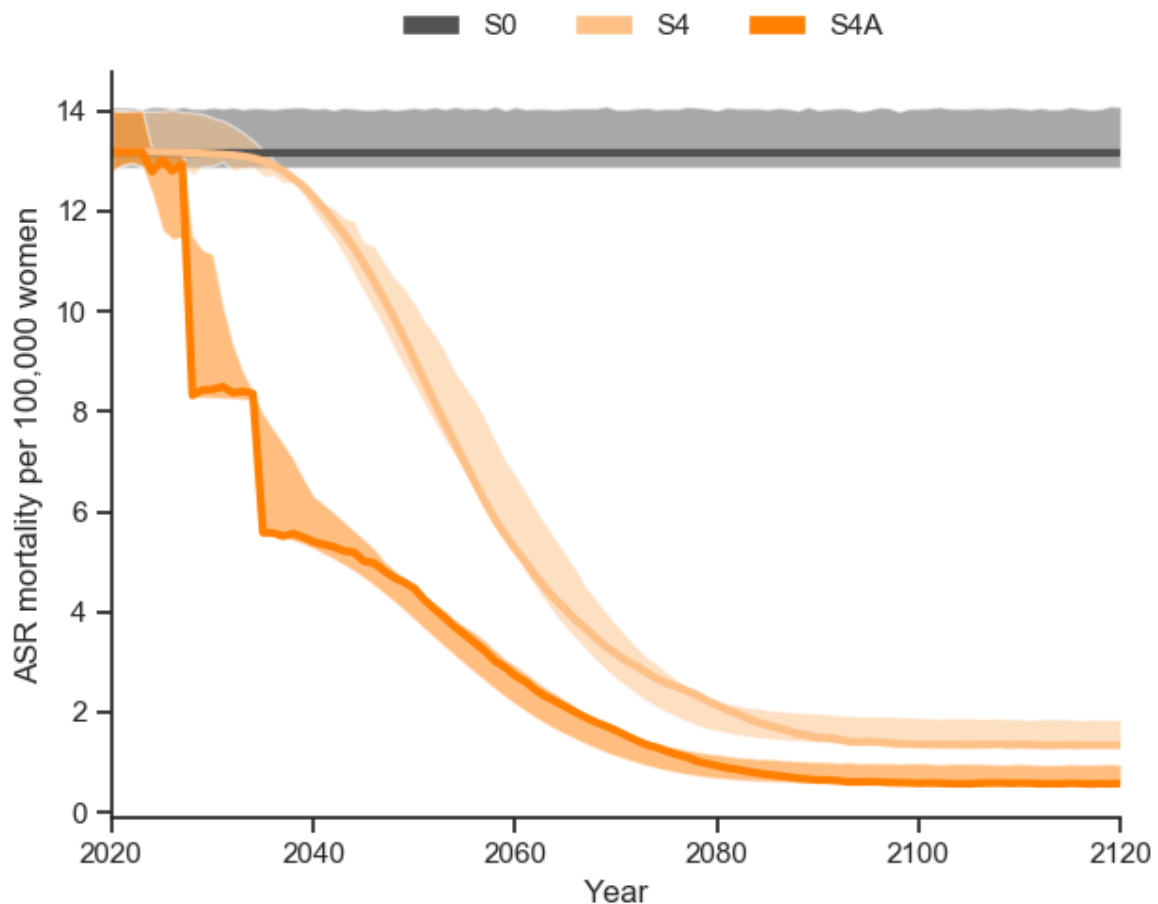
(e) Explanatory ‘build’ from status quo to show Scenario S1 alongside explanatory scenario S1A (same as S1 but with cancer treatment scaleup).



The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

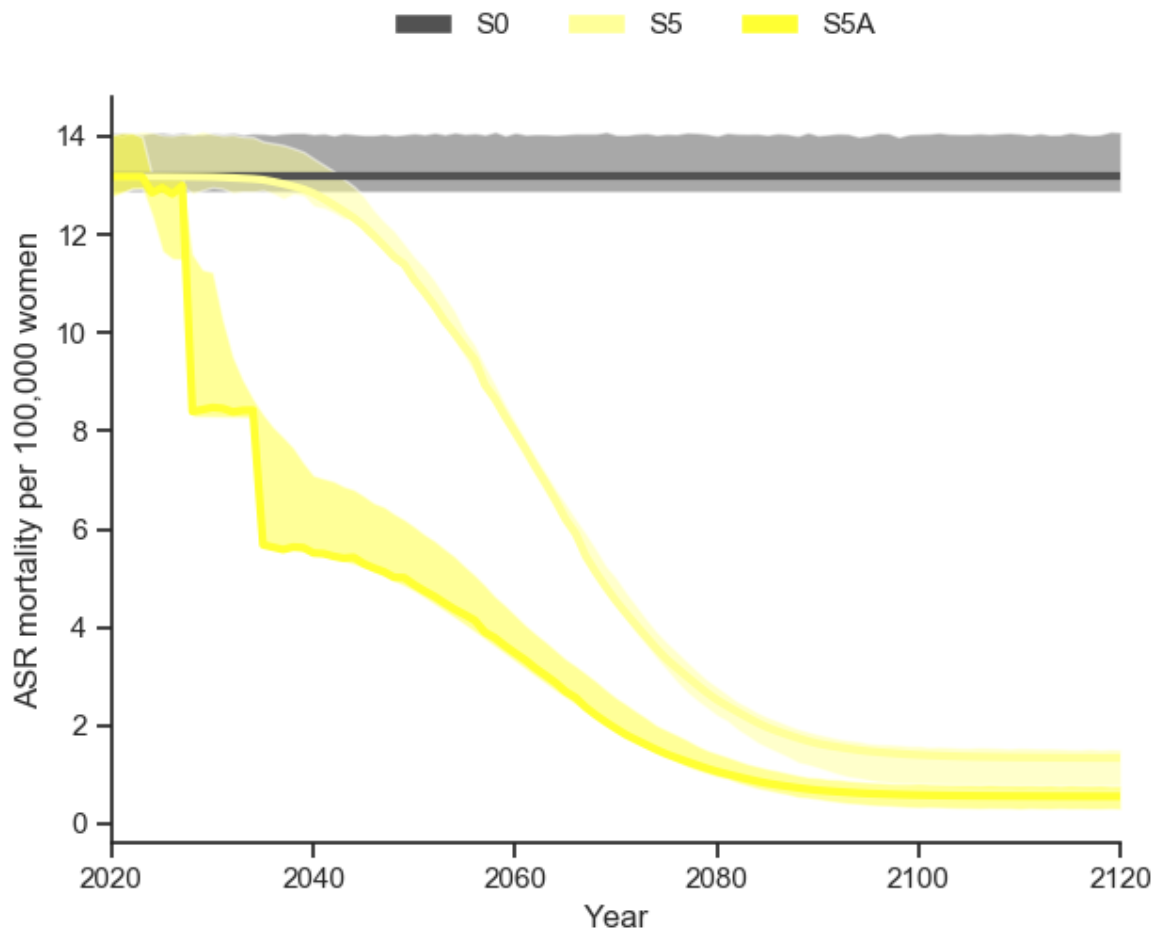
(f) Explanatory ‘build’ from status quo to show Scenario Supplementary S4 alongside explanatory scenario Supplementary S4A (same as Supplementary S4 but with cancer treatment scaleup).



The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

(g) Explanatory ‘build’ from status quo to show Scenario Supplementary S5 alongside explanatory scenario Supplementary S5A (same as Supplementary S5 but with cancer treatment scaleup).

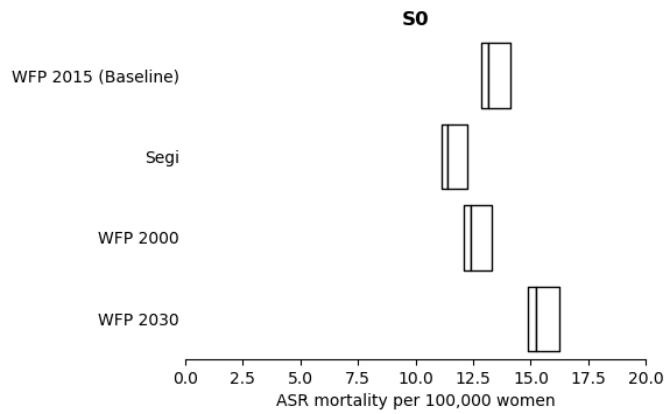


The solid lines indicate the median outcome of the three models; the shading indicates the range of the model outputs.

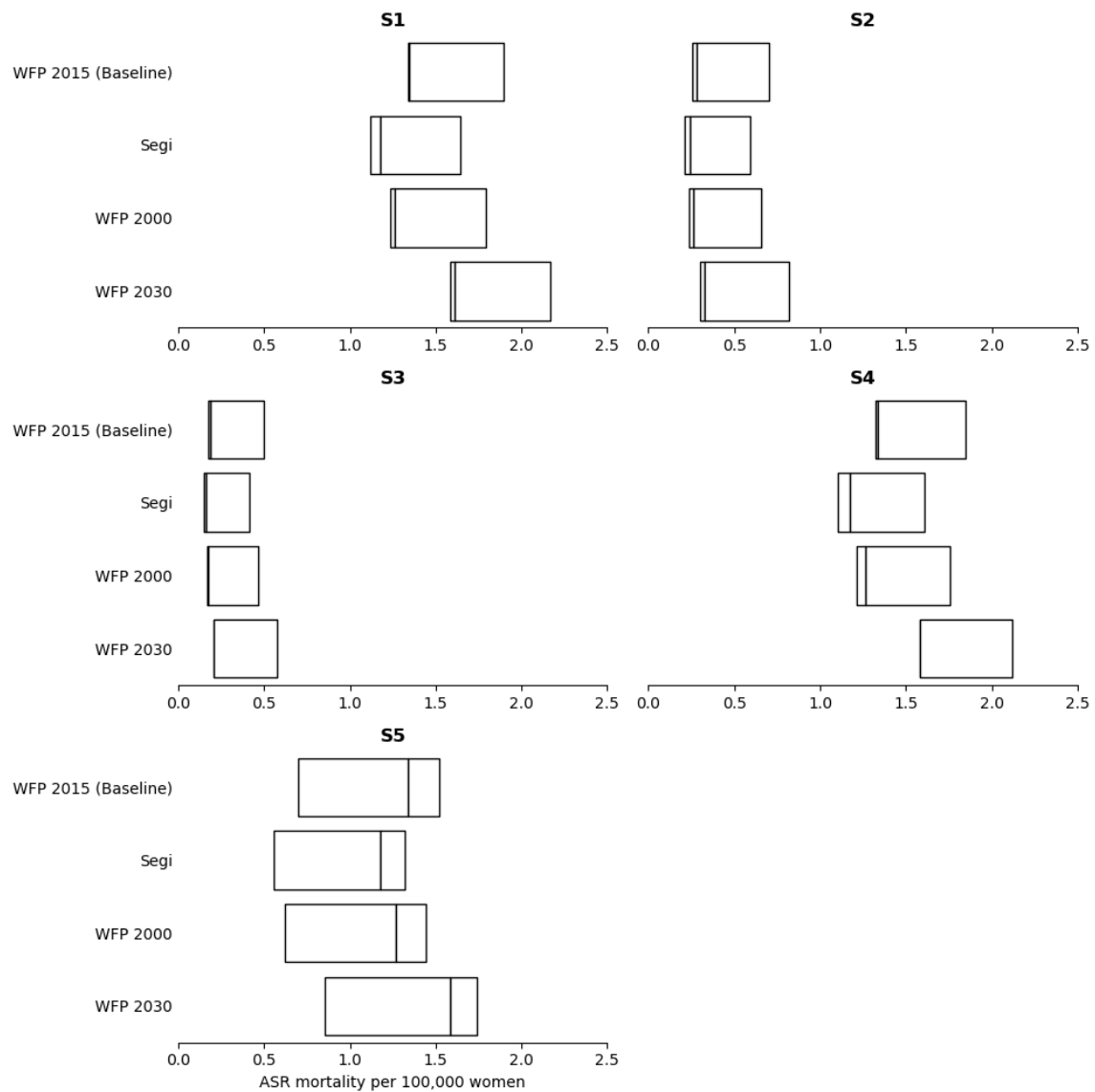
S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

**Figure AR4. Sensitivity analysis showing the impact of using different standard populations on the age-standardised rate of cervical cancer mortality in 2120: All-78 LMICs**

(a) Status quo



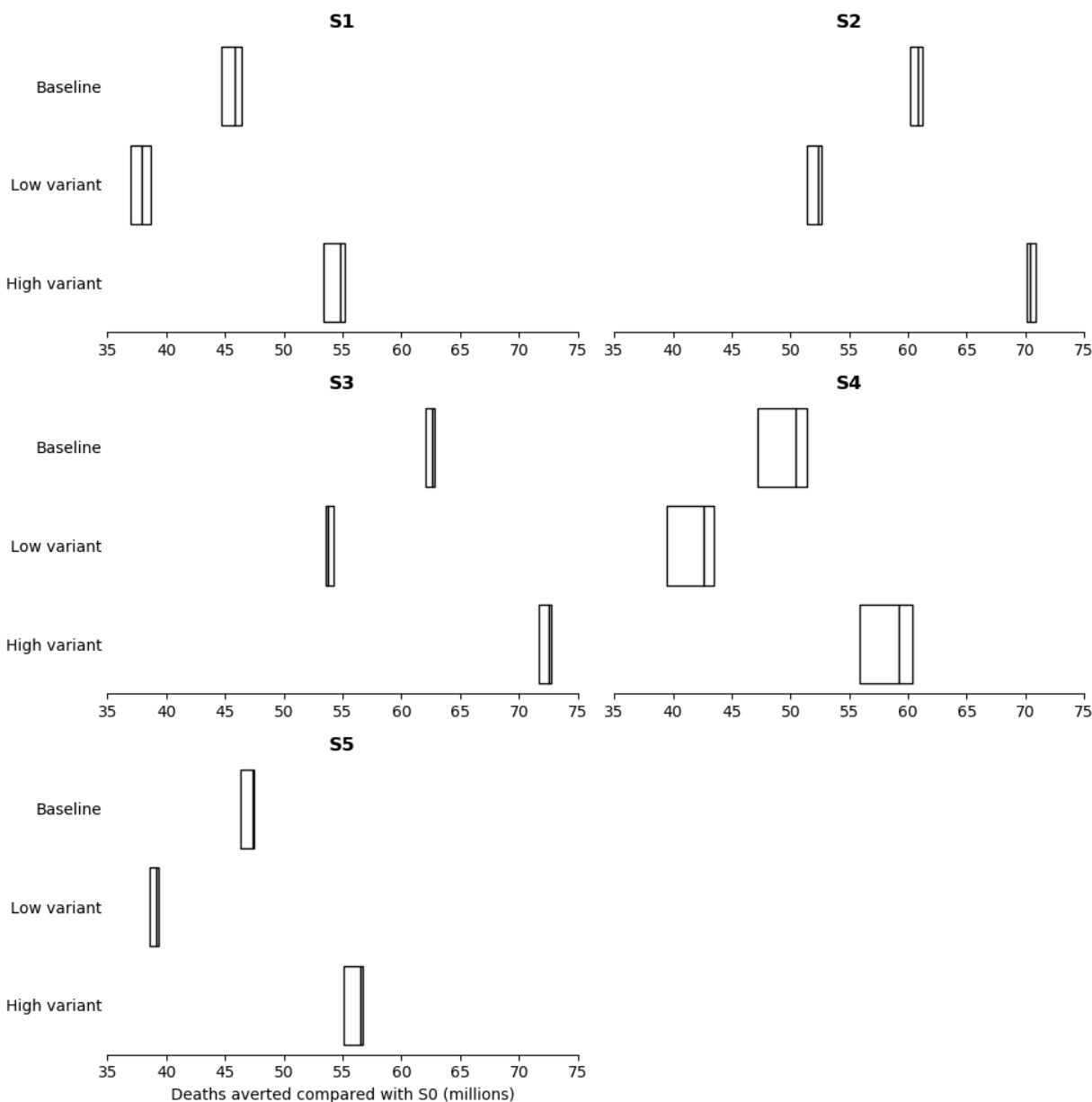
(b) Intervention scenarios



The middle line through each rectangular region represents the median predictions from all models; the outer lines represent the minimum and maximum values.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC catch-up to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC catch-up to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types. WFP = World Female Population.

**Figure AR5. Sensitivity analysis showing the impact of using the low fertility variant and high fertility variant population projections on the predictions of cumulative cancer deaths averted to 2120 (over the period 2020-2120): All-78 LMICs**



The middle line through each rectangular region represents the median predictions from all models; the outer lines represent the minimum and maximum values.

S0 = Status quo (no scale-up of vaccination, screening or treatment); S1 = female-only vaccination at 9 years with multi-age cohort (MAC) to age 14 years in 2020; S2 = female-only vaccination and once-lifetime HPV testing at age 35 years with cancer treatment scale-up; S3 = female-only vaccination and twice-lifetime HPV testing at age 35 and 45 years with cancer treatment scale-up; Supplementary S4 = female-only vaccination at 9 years with extended MAC to age 25 years in 2020; Supplementary S5 = female and male vaccination at 9 years with MAC to age 14 years in 2020. All vaccination strategies assume the use of a broad-spectrum HPV vaccine with protection against the seven oncogenic types.

## Part 2. Technical Appendix

### Section 1. Description of the 78 low- and lower-middle-income countries included in the analysis

**Table A1. Countries by geographic regions**

Geographic regions	Countries
East Asia & Pacific	Cambodia, Indonesia, Korea Democratic People's Republic, Lao People's Democratic Republic, Mongolia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Timor-Leste, Vanuatu, Vietnam
Europe & Central Asia	Georgia, Kyrgyz Republic, Moldova, Tajikistan, Ukraine, Uzbekistan
Latin America & Caribbean	Bolivia, El Salvador, Haiti, Honduras, Nicaragua
Middle East & North Africa	Arab Republic of Egypt, Djibouti, Morocco, Syrian Arab Republic, Tunisia, West Bank and Gaza, Republic of Yemen.
South Asia	Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka
Sub-Saharan Africa	Angola, Benin, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, eSwatini (formerly Swaziland), Ethiopia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Republic of the Congo, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Tanzania, The Gambia, Togo, Uganda, Zambia, Zimbabwe

Source: Group definitions are based on the regions used by The World Bank. (<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups> - <https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries>)

**Table A2. Countries by income groups**

Income groups	Countries
Low income	Afghanistan, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic People's Republic of Korea, Democratic Republic of the Congo, Eritrea, Ethiopia, Guinea, Guinea-Bissau, Haiti, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Republic of Yemen, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Syrian Arab Republic, Tajikistan, Tanzania, The Gambia, Togo, Uganda, Zimbabwe
Lower middle income	Angola, Arab Republic of Egypt, Bangladesh, Bhutan, Bolivia, Cabo Verde, Cambodia, Cameroon, Côte d'Ivoire, Djibouti, El Salvador, eSwatini (formerly Swaziland), Georgia, Ghana, Honduras, India, Indonesia, Kenya, Kyrgyz Republic, Lao People's Democratic Republic, Lesotho, Mauritania, Moldova, Mongolia, Morocco, Myanmar, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Philippines, Republic of the Congo, São Tomé and Príncipe, Solomon Islands, Sri Lanka, Sudan, Timor-Leste, Tunisia, Ukraine, Uzbekistan, Vanuatu, Vietnam, West Bank and Gaza, Zambia

Source: The World Bank (income groups are based on gross national income per capita; <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups> - <https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries>)

## Section 2. Population standardisation for estimates of cervical cancer elimination

Projections in cervical cancer incidence and mortality rates are being used to inform the WHO strategic planning process for cervical cancer elimination. There are two important reasons to standardise the population structure used for calculating cervical cancer rates in a country and into the future.

Firstly, the population used for standardisation will significantly impact the projected timeline to cervical cancer elimination for a given country, and it is therefore important that predictive evaluations which compare timing at a multi-country or global level use the same population for standardisation. While it is recognised that countries may additionally calculate rates using a local standardised population, this should only be used to inform planning within a country and is not appropriate for comparative discussions about cervical cancer rates or elimination timing at a global level.

Secondly, when calculating the age-specific rate of cervical cancer over a group of populations (for instance, combining country results to produce global estimates, or estimates across regions or income categories), countries with larger population size will be more highly weighted than smaller countries. When projecting forward in time, if the *population year* is not standardised, countries that are predicted to have a steeper increase in population size will contribute proportionately more to the overall rates over time, and therefore predicted age-standardised rates at the overall level may change over time *even in the absence of any changes in underlying risk of cervical cancer*, unless the year is standardised. Most of this is due to the fact that countries with the highest rates of cervical cancer (i.e. including some countries on sub-Saharan Africa) are predicted to experience the largest population growth over the remainder of the century. This effect is fully explained and illustrated in the Appendix of previously published single-model evaluation on the global timeline to elimination of cervical cancer.<sup>2</sup>

### Prior related work

A previously published single-model evaluation on the global timeline to elimination of cervical cancer<sup>2</sup> used the 2015 World Female Population (WFP2015) as the standard female population for elimination. In this prior analysis, it was shown that when using the Segi standard population (reflecting the 1960s population) then elimination was predicted to occur up to 5 years earlier than when using WFP2015. Conversely, when using a population structure predicted for the year 2030 obtained from the UN population projections, elimination was predicted to occur up to 5 years later. Another modelled analysis which predicted the timeline to elimination of cervical cancer in Australia found that the timeline to elimination was impacted by up to 7 years when using a structure which was equally weighted across all age-groups.<sup>3</sup>

The cervical cancer impact modelling performed for WHO by the CCEMC also uses the 2015 World Female Population (WFP2015) to estimate elimination timing.

### Summary of population standardisation recommendations for elimination

1. It is recommended that all estimates of cervical cancer incidence and mortality rates used to inform WHO strategic planning for cervical cancer elimination are age-and time-standardised and use the WFP2015 structure as described in Table A3.
2. It is further recommended that when estimating elimination across a group of countries (such as globally, or within a region), the WFP2015 population estimates for each country are used as the relative weightings for each country.
3. We suggest main results should be presented for all ages (0-99 years), and secondary results should be presented for ages 30-69 years.

**Table A3. Population structure for age-and-time standardisation rates for cervical cancer incidence and mortality**

Source: 2015 population estimates from the 2017 UN World Population Projections (downloaded 2017)

Age-group	Population denominator	Percent of population (%)*
0-4	325 428	8.9%
5-9	311 262	8.5%
10-14	295 693	8.1%
15-19	287 187	7.8%
20-24	291 738	8.0%
25-29	299 655	8.2%
30-34	272 348	7.4%
35-39	247 167	6.8%
40-44	240 167	6.6%
45-49	226 750	6.2%
50-54	201 603	5.5%
55-59	171 975	4.7%
60-64	150 562	4.1%
65-69	113 118	3.1%
70-74	82 266	2.2%
75-79	64 484	1.8%
80-84	42 237	1.2%
85-89	23 477	0.6%
90-94	9 261	0.3%
95-99	2 155	0.1%

\*Numbers may not add to 100% because of rounding.

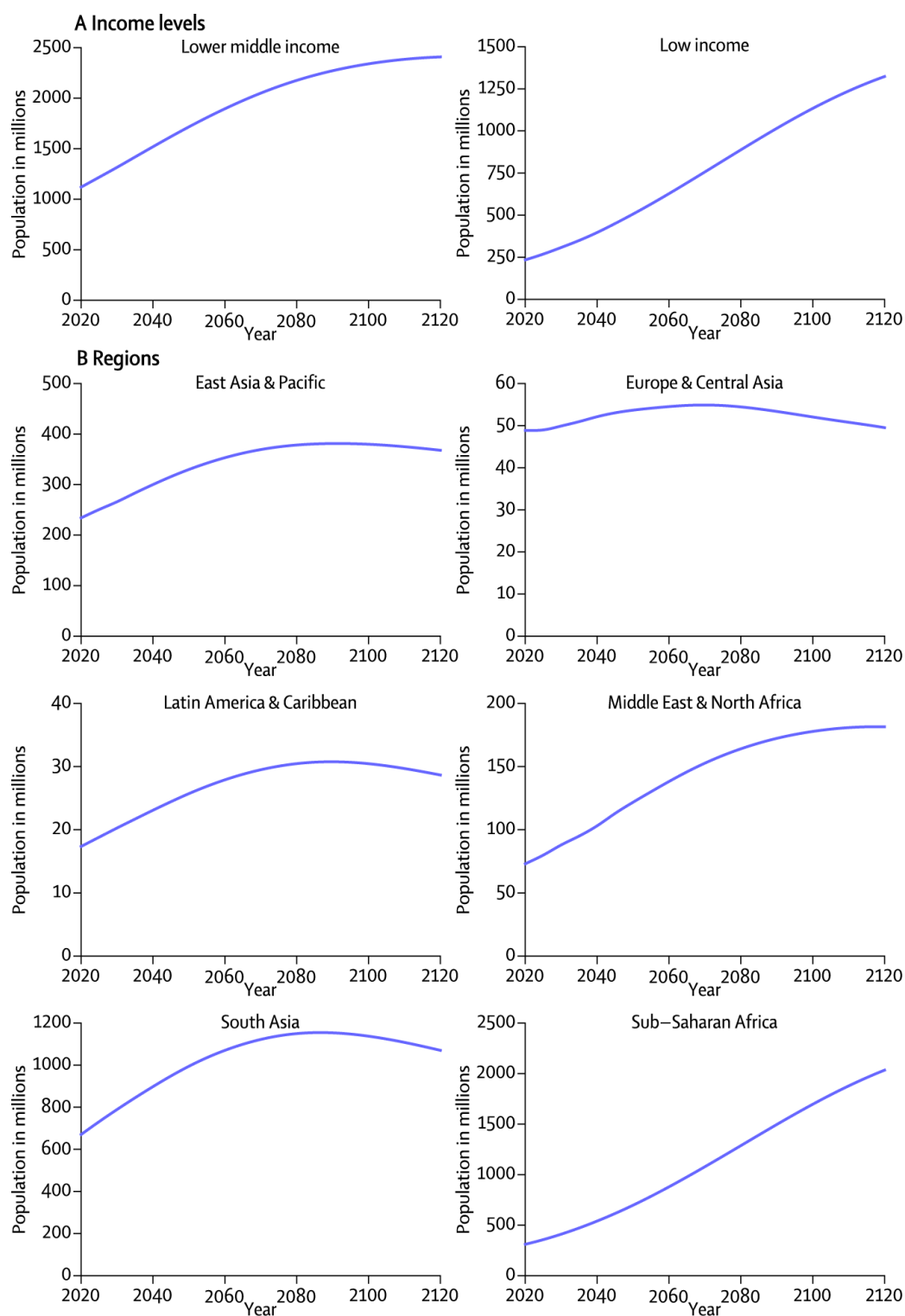
### Section 3. Population projections beyond 2100

The age-stratified population for all countries between 2020 and 2100 were taken from United Nations World Population Prospects: The 2017 Revision (using the medium variant projections; medium-fertility assumption, normal mortality and normal international migration). Because the CCEMC model projections of cervical cancer cases averted were to 2120 and population data were only available up to 2100, we extrapolated the United Nations World Population from 2100 to 2120.

To do this, first, we defined a population matrix  $(P_{a,y})$  representing the number of people of age group “a” (five-year age groups) at year “y” (between 2000-2100). Second, we defined the effective survival rates  $((S_{a,y}) = (P_{a+1,y}) / (P_{a,y-5}))$  as the ratio of the population of the subsequent age group over the population of the age group five years before. The effective birth rate  $((B_{0-4,y}) = (P_{0-4,y}))$  was defined as the 0-4 years old population. As survival and birth rates oscillate over time with different periods, we used Fourier analysis in the extrapolation process. The extrapolation of survival and birth rates after 2100 were performed in three steps: 1) for each age group, we removed the secular trend using a least-squares linear fit; 2) we performed a fast Fourier transform (FFT) and find local maxima in the power spectrum (dominant oscillatory components that have particular frequencies) that allowed us to define a least-squares fit (which is the sum of cosine functions representing each particular dominant frequency); and 3) we re-added the secular trend that was previously removed to these oscillatory components to get the full extrapolation results.

Using this method, we estimated the effective survival rates and the birth rate for years 2100 onwards for all age groups and countries. To get the projections for the population for years 2101 to 2120, we used the birth rates and the effective survival rates  $((P_{5-9,y}) = (B_{0-4,y-5}) \cdot (S_{0-4,y}))$ . Then, subsequent age group populations were obtained iteratively as  $((P_{a+1,y}) = (P_{a,y-5}) \cdot (S_{a,y}))$  (see Figure A1).

**Figure A1. Population predictions by income level and region**



## Section 4. Detailed model descriptions for the CCEMC models

### Policy1-Cervix (Cancer Council NSW, Australia)

A dynamic multicohort model of HPV transmission, HPV vaccination, cervical precancer, cancer survival, screening, diagnosis and treatment (*'Policy1-Cervix'*) was used for the evaluation. The model has been used for a wide range of evaluations, including recently being used to predict the timeline to elimination of cervical cancer for 181 countries<sup>2</sup> and for Australia.<sup>3</sup> It has been used for a range of government-commissioned on behalf of national cervical screening programs in Australia, New Zealand and England; some specific examples of this include: the effectiveness modelling and economic evaluation of cervical screening for both unvaccinated cohorts and cohorts offered vaccination, as part of the Renewal of the cervical screening program in Australia<sup>5</sup>, as well as similar screening policy evaluations for New-Zealand<sup>6</sup> and England<sup>7</sup>. It has also been used to inform provide estimates of resource utilization and disease impacts during the transition from cytology to HPV screening in Australia and New Zealand,<sup>8-10</sup> and to inform clinical management guidelines in Australia.<sup>11</sup> It has previously been extensively validated and used to evaluate changes to the cervical cancer screening interval in Australia and the United Kingdom,<sup>12,13</sup> the role of alternative technologies for screening in Australia, New Zealand and England,<sup>14-17</sup> the role of HPV triage testing for women with low-grade cytology in Australia and New Zealand,<sup>15,18</sup> the role of HPV testing for the follow-up management of women treated for cervical abnormalities<sup>19</sup> and the cost-effectiveness of alternative screening strategies and combined screening and vaccination approaches in China.<sup>20,21</sup> The model has also been used to evaluate female vaccination<sup>22</sup> and the incremental impact of vaccinating males in Australia,<sup>23</sup> the impact of the nonavalent HPV vaccine in four developed countries<sup>24</sup> and to assess the cost-effectiveness of the nonavalent HPV vaccine in Australia.<sup>25</sup> Predictions from the dynamic HPV transmission and vaccination model have also been validated against observed declines in HPV prevalence in women aged 18-24 years after the introduction of the quadrivalent vaccine.<sup>26</sup> Model predictions of age-specific cervical cancer incidence and mortality, the rate of histologically confirmed high-grade lesions per 1,000 women screened and overall screening participation rates have been previously validated against national data from Australia, England and New Zealand<sup>5-7</sup> after taking into account local age-specific screening behaviour obtained via analysis of screening registry data. Policy1-Cervix has also been used in conjunction with a model of fertility to estimate the impact of vaccination and screening changes on adverse pregnancy outcomes<sup>27</sup>, and with a model of HIV to estimate the impact of HIV control on future cervical cancer.<sup>28</sup> Ethnicity-specific models have been developed for New Zealand.<sup>29</sup>

The model simulates HPV infection which can persist and/or progress to cervical intraepithelial neoplasia grades I, II and III (CIN1, CIN2, CIN3); CIN 3 can then progress to invasive cervical cancer. Progression and regression rates between states are modelled separately for types HPV 16, HPV 18, other high-risk nonavalent-included types (31/33/45/52/58), and other non-nonavalent-included high risk types (Figure A2). We assumed precancer treatment is 100% successful at removing lesions. For women with CIN2 or CIN3, there is an 84.2% chance that the infection will also clear after treatment (100% chance of clearing the infection if treated for CIN1 or less). The model platform captures the increased risk of CIN2+ recurrence in successfully treated women (compared to the baseline risk of CIN2+ in the population), as previously described.<sup>30</sup> To capture the impact of HPV vaccination, we used a general dynamic transmission model, which assumes a median age of sexual debut of 16-17 for females and males, and a median lifetime number of sexual partners of 4 in females and 7 in males, with these numbers informed from sexual behaviour data from Australia. The dynamic transmission model stratified the population by sex, 5-year age group, and four sexual behaviour classes, each with varying levels of activity, defined by the annual number of new sexual partners. More details on the parameter assumptions for the dynamic model can be found in a previous publication.<sup>22</sup> This generalised sexual behaviour model was explicitly used to account for the additional effects of herd immunity through vaccination, which is a similar approach taken in our previous analysis on the timeline to elimination in 181 countries, and in which we found that substantially varying herd effects had minimal impact on predicted cases averted<sup>2</sup>.

For Policy1-Cervix, we additionally took into account regional differences in the attributable HPV types in cervical cancer, based on an international meta-analysis of HPV types in cancer by region (described in detail in our previous work<sup>2,31</sup>) We also assume that HPV types 16/18 are more common in cancers in younger women, based on the results from a systematic review and meta-analysis.<sup>32</sup> Therefore, our predicted reductions in cervical cancer incidence take account of the relative composition of the HPV types underlying cervical cancer in each country. Policy1-Cervix also accounted for a small amount of existing screening which has been reported for some countries in Europe and Central Asia and also in Latin America and Caribbean.

For each year, the cancer incidence rates by age in each country were scaled based on predicted changes due to vaccination, screening or trends, and were calculated as follows:

Let  $C_{i,j}$  represent cervical cancer rates for country  $C$ , for age-group  $i$  and in year  $j$ , where  $i \in \{10-14, 15-19, \dots, 95-99\}$  and  $j \in \{2020, 2021, \dots, 2020\}$ .

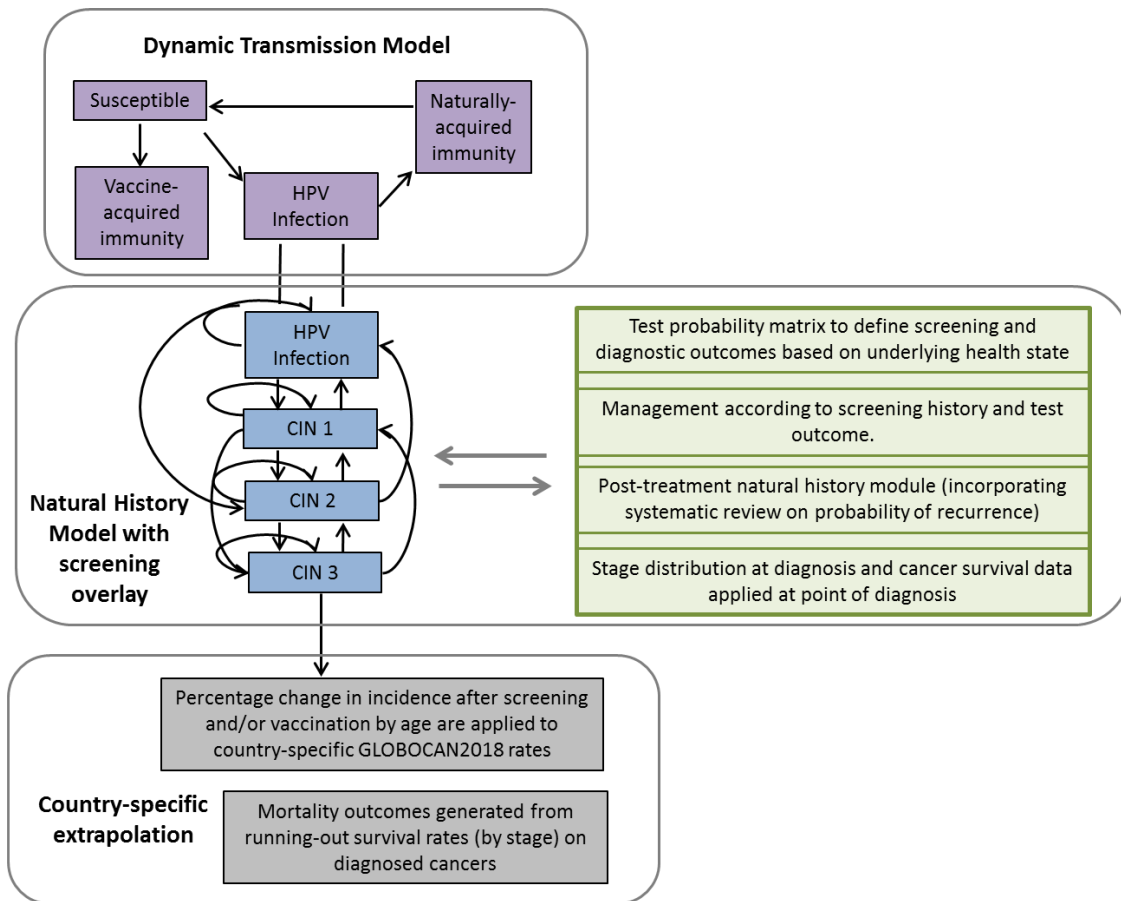
Let  $SVT_{i,j}$  represent the relative change in cancer rates for age-group  $i$  and year  $j$  after a combination of vaccination (including herd immunity effects), screening or cancer treatment scale-up as predicted using *Policy1-Cervix*.

Then for any age-group  $i$  and year  $j$  we obtain the predicted rate of cervical cancer for country  $C$  as follows:

$$C_{i,j} = C_{i,2018} * SVT_{i,j}$$

Where  $C_{i,2018}$  are obtained from GLOBOCAN 2018 estimates.

Figure A2. Model structure - Policy1-Cervix



## Harvard model (Harvard University, USA)

As previously described<sup>33</sup>, we used a multi-modelling approach to project the population health and economic consequences for alternative cervical cancer elimination scenarios over time. Our multi-modelling framework involves a dynamic transmission model of HPV transmission (“Harvard-HPV”), an individual-based model of cervical carcinogenesis (“Harvard-CC”), and a companion multi-country population model (“Harvard-Scale Up”) (Figure A3). The Harvard models have been used together and independently for cervical cancer screening and HPV vaccination policy analyses in high-income countries such as the United States<sup>34</sup> and Norway<sup>35</sup>, in lower-income settings such as Uganda<sup>33</sup>, India<sup>36</sup>, as well as multi-country level analyses for Gavi-eligible countries<sup>37</sup>.

Briefly, Harvard-HPV is an individual (i.e., agent-based) dynamic model that simulates heterosexual partnership acquisition and dissolution, and independent transmission of seven HPV genotypes (HPV-16, -18, -31, -33, -45, -52, -58). Individuals are stratified by sex, age, and sexual activity category (SAC; four categories: none (0), low (1), medium (2), high (3)), which govern initial sexual mixing in the population. Harvard-CC is an individual-based stochastic model that simulates HPV-induced cervical carcinogenesis associated with all HPV types<sup>38</sup>. Health states in the model, descriptive of each patient’s underlying true health, include infection status, grade of cervical intraepithelial neoplasia (CIN), and stage of cancer. HPV types are stratified as HPV-16; -18; -31; -33; -45; -52; -58; pooled other high-risk infections; and pooled low-risk infections. The probabilities governing the model transitions depend on age; HPV type; duration of HPV infection; type-specific natural immunity; as well as a woman’s history of prior infection; and previously treated CIN. For women successfully treated for CIN, 30% of the women are assumed to not clear their HPV infection, placing them at an elevated risk of progressing back to a CIN compared with the general population. Harvard-Scale Up is a multi-cohort companion model that captures important country- and region-specific variations (e.g., population size, cervical cancer burden) in each of the individual LMICs.

Harvard-HPV was used to project reductions in HPV incidence by genotype and age over time associated with each of the elimination scenarios; these reductions served as inputs into Harvard-CC. Harvard-CC was then used to project reductions in cervical cancer incidence by genotype and age over time for each of the elimination scenarios; these reductions served as inputs into Harvard-Scale Up. Finally, Harvard-Scale Up was used to estimate country-specific changes in cervical cancer incidence, taking into consideration demographic changes over time.

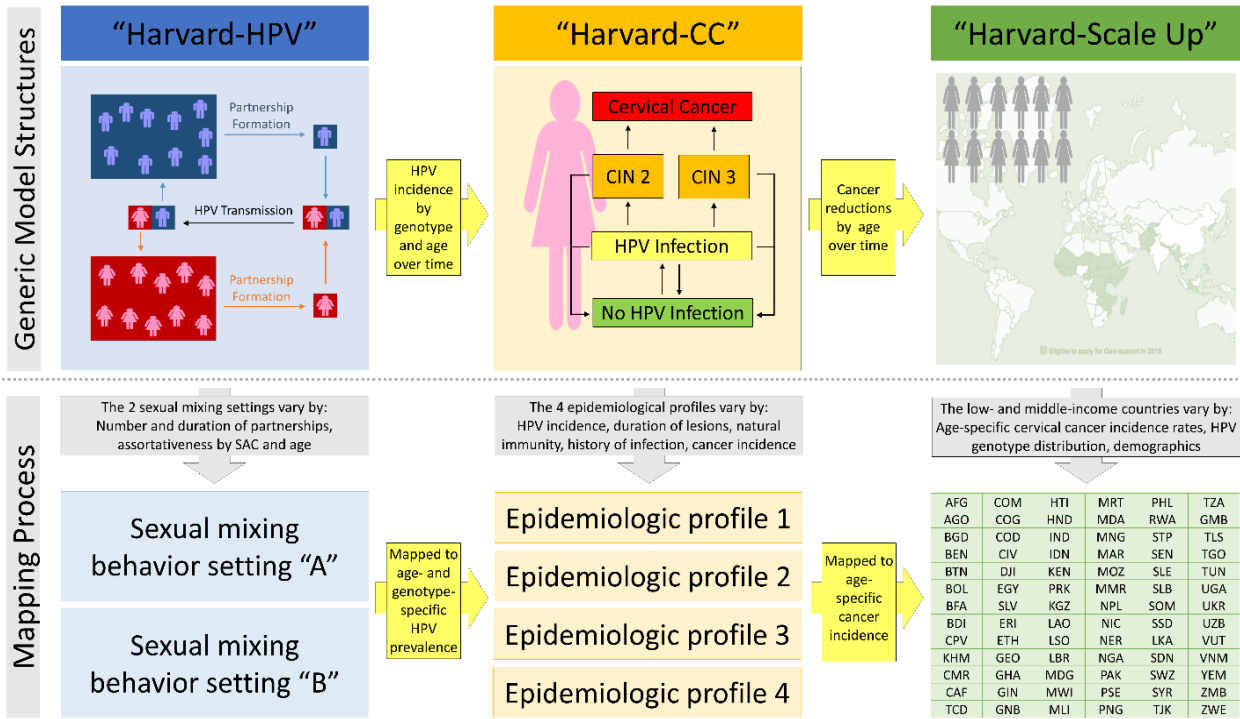
Both the Harvard-HPV and Harvard-CC models require highly detailed data on sexual behaviour and cervical cancer epidemiology that are limited in most LMICs. We therefore employed two calibrated Harvard-HPV models and four calibrated Harvard-CC models adapted to settings where data permitted calibration (El Salvador, India, Nicaragua, Uganda) to capture variation in sexual behaviour and cervical cancer epidemiological profiles across settings.

To project country-specific changes in cervical cancer incidence under alternative elimination scenarios in each of the 78 LMICs, we took a three-step approach:

1. For each vaccination and screening scenario, we estimated the age- and genotype-specific percentage changes in the incidence of HPV infection over time using Harvard-HPV compared with no current screening or HPV vaccination coverage.
2. We relied on a mapping process (see Figure A3) to link the Harvard-HPV model to the Harvard-CC model based on trends in age- and genotype-specific HPV prevalence. The outputs from *Step 1* (percentage changes in HPV incidence) were applied to the corresponding HPV incidence inputs in Harvard-CC (from the four epidemiological profiles) to estimate reductions in cervical cancer incidence by age and stage over time.
3. We then mapped Harvard-CC to each individual LMIC in Harvard-Scale Up using cervical cancer incidence among women ages 40-59. We assigned each LMIC to one of the four Harvard-CC profiles using minimum sum of square differences between incidence in each individual LMIC (from GLOBOCAN 2018) and the four Harvard-CC profiles. To estimate the impact of vaccination and screening on country-specific cervical cancer incidence rates over time, we applied the relative reductions over time estimated in *Step 2* from the four profiles to each LMIC based on the mapping. The reductions associated with each scenario were calculated relative to a scenario assuming no current screening or HPV vaccination coverage; however, these reductions were then applied to country-specific cancer incidence rates that implicitly accounted for ongoing (often very low-coverage) screening and vaccination preventive measures.

To project country-specific changes in cervical cancer mortality under alternative elimination scenarios in each of the 78 LMICs, we calibrated the regional 5-year survival probabilities (see main manuscript) in order to fit the country-specific GLOBOCAN 2018 age-specific cancer mortality rates per 100,000 women.

**Figure A3. Model structure – Harvard model**



## **HPV-ADVISE: Agent-based Dynamic model for Vaccination & Screening Evaluation (Laval University, Canada)**

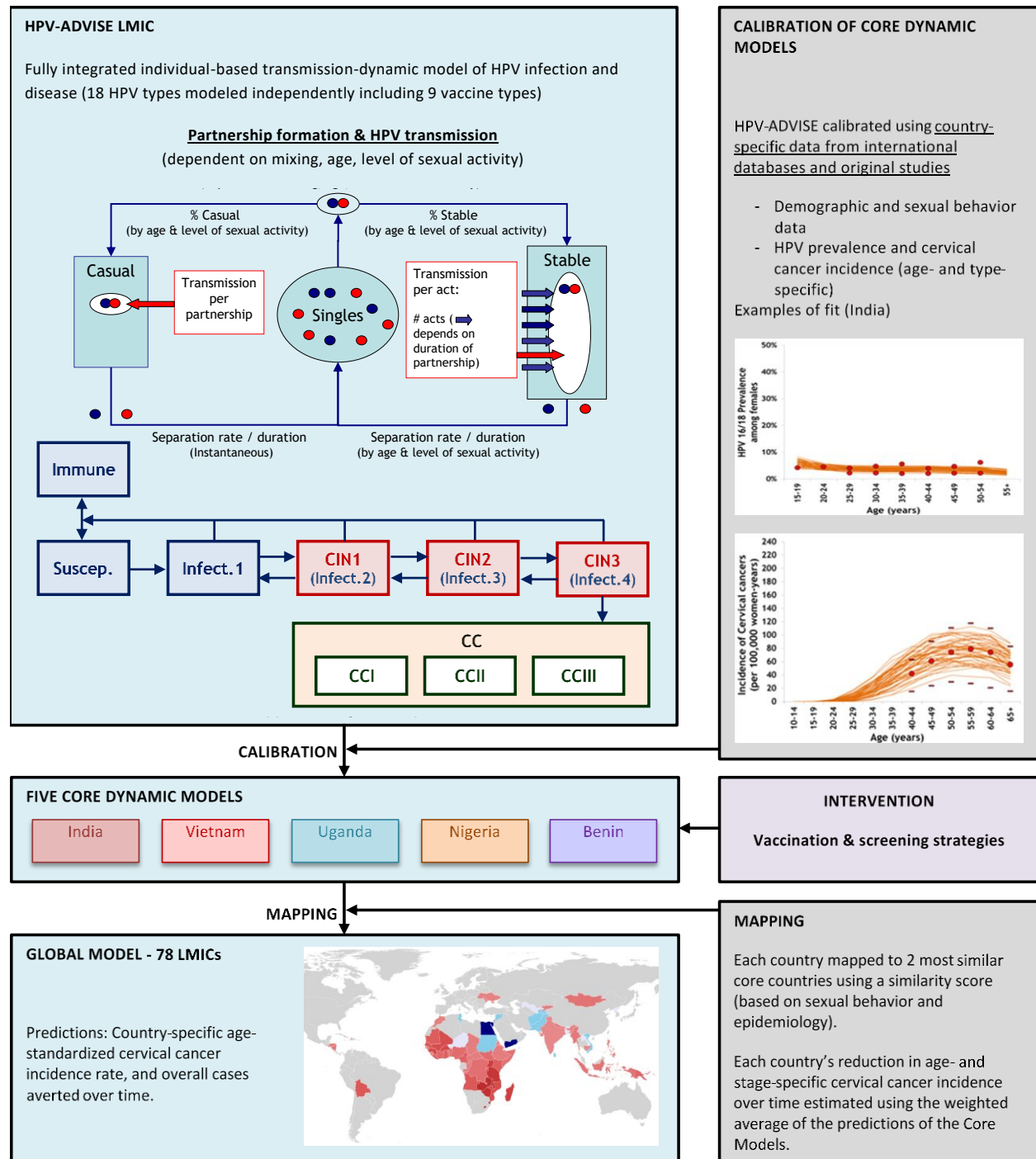
HPV-ADVISE GLOBAL was used to predict the population-level effectiveness of different cervical cancer elimination scenarios over time. The overall approach was to generalize the predictions from 5 core transmission dynamic models of HPV infection and natural history of cervical cancer (5 Core HPV-ADVISE LMIC models) to 78 LMICs, based on country-specific sexual behavior, HPV prevalence, and cervical cancer incidence (see Figure A4 and the “Technical Appendix HPV-ADVISE LMIC” for a detailed description of methods; <http://www.marc-brisson.net/HPVadvise-LMIC.pdf>).<sup>39</sup>

HPV-ADVISE GLOBAL is based on 5 Core HPV-ADVISE LMIC models calibrated to highly stratified data from India, Vietnam, Uganda, Nigeria, and Benin to reproduce country-specific: 1) demography; 2) sexual behavior; 3) HPV transmission & natural history of disease and; 4) screening and treatment. Briefly, HPV-ADVISE LMIC models are individual-based, transmission-dynamic models of multi-type HPV infection and diseases. The models simulate HPV transmission through sexual activity. Sexual partnership formation and dissolution are explicitly modeled, and based on different risk groups (including female sex workers) and sexual mixing. A total of 18 different genotypes are modeled individually. HPV-ADVISE LMIC reproduces genotype-specific natural history of cervical cancer from HPV infection to cervical cancer via precancerous cervical lesions (grade I, II and III). The models also reproduce complex cervical screening and treatment algorithms at the individual level, by tracking and simulating each woman’s screening history.

For the global modeling analysis, country-specific predictions of the impact of vaccination and screening on cervical cancer incidence and mortality were performed using a 5-step approach:

1. Each of the 78 LMICs was mapped to the five core HPV-ADVISE LMIC models through a ranking process based on similarity in terms of sexual behavior, HPV prevalence, HPV type distribution and cervical cancer incidence. The sexual behavior and epidemiological outcomes used to determine the ranking were: 1) Female mean lifetime number of sexual partners (obtained from USAID's DHS Program<sup>40</sup> for the majority of countries or from specific studies<sup>41-48</sup>), 2) Adjusted HPV prevalence by world region<sup>49</sup>, 3) Percentage of cervical cancer positive for HPV16/18/31/33/45/52/58 by world region<sup>51</sup>, 4) Age-standardized cervical cancer incidence rate<sup>50,51</sup>. For each country, overall ranking scores were computed by 1) estimating the absolute difference between its outcomes and those from the 5 countries represented by the core models (India, Vietnam, Uganda, Nigeria, and Benin), 2) for each outcome, ranking the countries’ similarity to each core model country from 1 (most similar) to 5 (least similar), and 3) using the average ranking over the 4 outcomes as a global score. For example, for Côte d’Ivoire, the average rankings over the 4 outcomes associated with the Benin, Nigeria, Uganda, India, and Vietnam models were 1.5, 1.8, 3.0, 3.8, and 4.2, respectively.
2. Each of the 78 LMICs was assigned to the 2 most similar core HPV-ADVISE LMIC models based on the average ranking score. For Côte d’Ivoire, the 2 core models were those calibrated to Benin and Nigeria.
3. For each vaccination and screening scenario, we estimated the age- and stage-specific percentage reductions in the incidence of cervical cancer over time using the 5 core HPV-ADVISE LMIC models. Of note, each core model has 50 parameter sets representing uncertainty in sexual behavior and natural history parameters as well as variability in epidemiology within countries. Hence, there were 50 predictions per scenario per core model.
4. For each of the 78 LMICs, we estimated the percentage reductions in age- and stage-specific cervical cancer incidence over time using the weighted average of the predictions of the 2 core HPV-ADVISE LMIC models selected in Step 2. The percentage reductions were based on 60% of the results from the core model with the most similar ranking and 40% from the other model.
5. To estimate the impact of vaccination and screening on cervical cancer incidence rates over time, we applied the relative reductions over time estimated in Step 4 to the country-, age- and stage-specific cervical cancer incidence and mortality estimated from GLOBOCAN 2018.<sup>50,51</sup>

**Figure A4. Model structure - HPV-ADVISE**



## Section 5. Detailed description of modelled scenarios (including *status quo*, core, supplementary, and explanatory scenarios)

The CCEMC models projected reductions in age-standardised cervical cancer mortality and deaths averted over time in 78 LMICs using standardised scenarios. The definition and selection of scenarios for the mortality analysis was determined after consultation at several WHO technical expert, advisory group and global stakeholder meetings in 2018 and was based on a multi-step process previously articulated for the companion analysis of cervical cancer incidence. In brief, an initial exploratory analysis involving 40 standardised vaccination and screening scenarios was used to identify strategies likely to lead to elimination; from this process, three core vaccination and cervical screening scenarios were identified, and these scenarios were then used for the analysis of cervical cancer elimination. The current mortality analysis encompassed these three standardised core scenarios, but for screening scenarios involving scale-up of precancer treatment services, we further articulated and developed model structure to simulate the mortality impact of achieving targets for scale-up of treatment for cervical precancers, for screen-detected invasive cancers, and for clinically-detected (symptomatic) cancers. Our modelled scenarios were aligned with the scale-up targets articulated in the WHO draft strategic plan for elimination.<sup>52</sup>

### *Status quo, core and supplementary scenarios*

#### *Status quo*

For impact evaluation, the main comparator – S0 (*'status quo'*) for this analysis assumed no scale-up of vaccination, screening or treatment. With respect to screening, two models (*Policy1-Cervix* and *HPV-Advise*) took into account existing levels of coverage for the status quo (refer to model descriptions in Section 4).

#### *Core scenarios*

The final fully articulated core scenarios for the mortality impact analysis were: 'S1': Ongoing girls-only vaccination at age 9 years with multi-age cohort (MAC) catch-up in the first year for ages 10-14 years, 'S2': Girls-only vaccination, once-lifetime screening at around 35 years with precancer treatment as appropriate, and invasive cancer treatment (and palliative care) scale-up, and 'S3': Girls-only vaccination, twice-lifetime screening at around 35 and 45 years with precancer treatment as appropriate, and invasive cancer treatment (and palliative care) scale-up.

Girls are assumed to be vaccinated at age 9 years with a one-year catch-up to age 14 years, ie multi-age cohort (MAC) vaccination, assuming 90% coverage and 100% lifetime protection against HPV16/18/31/33/45/52/58. Cervical screening is assumed to involve HPV testing (or another test with equivalent sensitivity and specificity characteristics) once or twice per lifetime (as appropriate to the scenario) at ages 35 and 45 years with increasing uptake from 45% (2023), 70% (2030) and to 90% (2045) in scenarios 2 and 3. For these scenarios (S2 and S3), treatment for screen-detected precancer/cancer is assumed to have a scale-up rate reflecting that of screening scale-up (and for screen-detected cancer, 90% will be treated), which is 45% (2023), 70% (2030) and 90% (2045). For clinically/symptomatically detected cancer, it is assumed that the treatment access rate will ramp up from 50% in 2023 and 90% in 2030.

#### *Supplementary vaccination scenarios*

We also considered two supplementary vaccination scenarios: 'Supplementary S4': girls-only vaccination at age 9 years with MAC catch-up in the first year for ages 10-25 years, and 'Supplementary S5': girls & boys vaccination at age 9 years with MAC catch-up in the first year for ages 10-14 years.

The core and supplementary scenarios are summarised in Table A4.

Vaccination was assumed to scale-up to 90% coverage from 2020 with 100% lifetime broad spectrum protection against HPV16/18/31/33/45/52/58 in individuals susceptible to the relevant type; the analysis thus applies to any broad spectrum vaccine that protects against oncogenic types 16/18/31/33/45/52/58 either by direct protection (per second generation nonavalent vaccine) or potentially via cross-protection for some non-vaccine-included types.<sup>53</sup> In terms of number of doses, we assumed that efficacy was achieved with 2 doses for vaccine recipients age <15 years, 3 doses for older vaccine recipients (although dose-delivery was not explicitly modelled).

Cervical screening was assumed to involve HPV testing once or twice per lifetime at around ages 35 and 45 years with increasing uptake from 45% (2023) to 70% (2030) to 90% (2045+), assuming 90% of screen-detected

precancers were effectively treated. Sensitivity of HPV testing was assumed to be 90% for CIN2 and 94% for CIN3+ and assumed to be independent of age. We assumed no sensitivity loss from triaging – i.e. implicitly, we assumed only Visual Assessment for Treatment (VAT) (i.e. visual inspection performed only to determine the appropriate type of treatment, exclude the possibility of a large precancerous lesion being present requiring referral for loop excision, or a frank invasive cancer being present which would require the women to be referred to invasive cancer treatment services). All screening intervention scenarios assumed that 90% of HPV screen-positive women would receive appropriate assessment via visual inspection and appropriate treatment as required for pre-cancer or cancer. For successfully delivered pre-cancer treatment, treatment success rates were assumed to be 100%; CCMEC groups differed in their modelling of post-treatment natural history in terms of whether an elevated risk of recurrence was simulated (see *Technical Appendix: Section 4* for details).

Modelling of the mortality impact of cancer treatment scale-up also assumed that 50% of women with clinically-detected invasive cervical cancers would have access to high quality surgery, radiotherapy, chemotherapy by 2023, and 90% by 2030. We assumed that scale-up occurs in stepwise fashion to 50% from 2023-2029 and then to 90% for years 2030 and beyond. Once treatment access was scaled-up to 90% in 2030, 10-year survival was assumed to increase to 78%, 69%, 52% and 8% for women diagnosed at FIGO Stages 1, 2, 3-4A, 4B respectively (*Technical Appendix, Table A6*). Note that we assumed that women of all ages and comorbidity status would experience this level of improved survival in scenarios with cancer treatment scale-up.

The choice of final interventions, or combination of interventions, to be assessed in this mortality impact analysis, took into account the feasibility and acceptability around whether interventions could be considered in isolation from each other. Vaccination can be considered as a single intervention since it is purely prophylactic and does not require referral to precancer or cancer treatment services as part of the pathway for effective delivery. By contrast, population-wide implementation of cervical screening necessarily leads to the screening-related detection of invasive cervical cancer (with favourable effects on stage-shifting) as well as to precancer detection. Referral pathways must be organized to ensure that women with screen-detected invasive cancer are offered prompt and effective treatment (with treatment capacity scaling up as screening expands) since this then leads to improved survival outcomes. Therefore, for this analysis of mortality impact we considered two basic types of ‘intervention packages’ – either vaccination alone, or vaccination combined with cervical screening and treatment for precancer and screen-detected cancer, delivered in conjunction with scaled-up treatment services for clinically-detected cancers.

### **Explanatory scenarios**

For explanatory purposes only, to understand the relative contributions of each type of intervention to outcomes over time, we also modelled some additional scenarios. These scenarios (S0A, S1A, S2A, S3A, S4A, S5A), used the same assumptions as for the relevant main *status quo*, core or Supplementary scenario, except the opposite assumption for treatment of clinical/symptomatically detected cancer was made. The full description of all explanatory scenarios is provided in Table A5.

**Table A4. Summary of status quo, core and supplementary scenarios considered**

Scenario	Vaccination							Screening			Treatment		
	Vaccine type	Vaccine duration	Vaccine efficacy	Vaccination age (Routine + 1 year MAC)	Coverage (routine)	Coverage (MAC)	Gender	Coverage	Ages	Frequency per lifetime	Detected precancer	Clinically/ symptomatically detected cancer	Confirmed cancer detected via screening pathway
S0 Status quo (Comparator) No scale-up of vaccination, screening or treatment	None	N/A	N/A	N/A	N/A	N/A	N/A	No ramp up	N/A	N/A	N/A	No ramp up	N/A
S1 Girls vaccination	Broad spectrum *	Lifetime	100%	9 + 10-14	90%	90%	Female	No ramp up	N/A	N/A	N/A	No ramp up	N/A
S2 Girls vaccination and 1x screening with clinically detected cancer treatment scale-up	Broad spectrum *	Lifetime	100%	9 + 10-14	90%	90%	Female	45% (2023), 70% (2030) and 90% (2045)	35 years	1X	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated	50% (2023), 90% (2030)	Scales up with screening scale-up; of screen-detected cancer, 90% treated
S3 Girls vaccination and 2x screening with clinically detected cancer treatment scale-up	Broad spectrum *	Lifetime	100%	9 + 10-14	90%	90%	Female	45% (2023), 70% (2030) and 90% (2045)	35, 45 years	2X	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated	50% (2023), 90% (2030)	Scales up with screening scale-up; of screen-detected cancer, 90% treated
Supplementary S4 Girls vaccination with extended MAC catch-up without clinically detected cancer treatment scale-up	Broad spectrum *	Lifetime	100%	9 + 10-25 (NOTE: assume 3-dose vaccination 15-25 years)	90%	90%	Female	No ramp up	N/A	N/A	N/A	No ramp up	N/A
Supplementary S5 Girls and boys vaccination	Broad spectrum *	Lifetime	100%	9 + 10-14	90%	90%	Female & Male	No ramp up	N/A	N/A	N/A	No ramp up	N/A

MAC: Multi-age cohort; N/A: Not applicable;

\*Considers any broad-spectrum vaccine that protects against oncogenic types HPV16/18/31/33/45/52/58 either by direct protection (as per second generation nonavalent vaccine) or potentially via cross-protection for non-vaccine-included types.

**Table A5. Detailed description of status quo, core, supplementary and exploratory scenarios considered**

Scenario	Vaccination							Screening			Treatment		
	Vaccine type	Vaccine duration	Vaccine efficacy	Vaccination age (Routine + 1 year MAC)	Coverage (routine)	Coverage (MAC)	Gender	Coverage	Ages	Frequency per lifetime	Detected precancer	Clinically/symptomatically detected cancer	Confirmed cancer detected via screening pathway
S0 Comparator: no scale-up of vaccination, screening or treatment	None	N/A	N/A	N/A	N/A	N/A	N/A	No ramp up	N/A	N/A	N/A	No ramp up	N/A
S0A Clinically detected cancer treatment scale-up only	None	N/A	N/A	N/A	N/A	N/A	N/A	No ramp up	N/A	N/A	N/A	50% (2023), 90% (2030)	N/A
S1 Girls-only vaccination	‘broad spectrum’ against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female	No ramp up	N/A	N/A	N/A	No ramp up	N/A
S1A Girls-only vaccination with clinically detected cancer treatment scale-up	‘broad spectrum’ against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female	No ramp up	N/A	N/A	N/A	50% (2023), 90% (2030)	N/A
S2 Girls vacc and 1x screening with clinically detected cancer treatment scale-up	‘broad spectrum’ against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female	45% (2023), 70% (2030), and 90% (2045)	35 years	1x	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated	50% (2023), 90% (2030)	Scales up with screening scale-up; of screen-detected cancer, 90% treated
S2A Girls vaccination and 1x screening without clinically detected cancer treatment scale-up	‘broad spectrum’ against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female	45% (2023), 70% (2030), and 90% (2045)	35 years	1x	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated	No ramp up	Scales up with screening scale-up; of screen-detected cancer, 90% treated

Scenario	Vaccination							Screening			Treatment		
	Vaccine type	Vaccine duration	Vaccine efficacy	Vaccination age (Routine + 1 year MAC)	Coverage (routine)	Coverage (MAC)	Gender	Coverage	Ages	Frequency per lifetime	Detected precancer	Clinically/symptomatically detected cancer	Confirmed cancer detected via screening pathway
S3 'ALL-IN' Girls vaccination and 2x screening with clinically detected cancer treatment scale-up	'broad spectrum' against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female	45% (2023), 70% (2030), and 90% (2045)	35, 45 years	2x	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated	50% (2023), 90% (2030)	Scales up with screening scale-up; of screen-detected cancer, 90% treated
S3A Girls vaccination and 2x screening without clinically detected cancer treatment scale-up	'broad spectrum' against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female	45% (2023), 70% (2030), and 90% (2045)	35, 45 years	2x	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated	No ramp up	Scales up with screening scale-up; of screen-detected cancer, 90% treated
Supplementary S4 Girls vacc with extended MAC catchup without clinically detected cancer treatment scale-up	'broad spectrum' against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-25 (NOTE: assume 3-dose vaccination 15-25 years)	90%	90%	Female	No ramp up	N/A	N/A	N/A	No ramp up	N/A
Supplementary S4A Girls vaccination with extended MAC catchup with clinically detected cancer treatment scale-up	'broad spectrum' against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-25 (NOTE: assume 3-dose vaccination 15-25 years)	90%	90%	Female	No ramp up	N/A	N/A	N/A	50% (2023), 90% (2030)	N/A

Scenario	Vaccination							Screening			Treatment		
	Vaccine type	Vaccine duration	Vaccine efficacy	Vaccination age (Routine + 1 year MAC)	Coverage (routine)	Coverage (MAC)	Gender	Coverage	Ages	Frequency per lifetime	Detected precancer	Clinically/symptomatically detected cancer	Confirmed cancer detected via screening pathway
Supplementary S5 Girls and boys vaccination without clinically detected cancer treatment scale-up	‘broad spectrum’ against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female & Male	No ramp up	N/A	N/A	N/A	No ramp up	N/A
Supplementary S5A Girls and boys vaccination with clinically detected cancer treatment scale-up	‘broad spectrum’ against types involved in 90% of cervical cancer	Lifetime	100%	9 + 10-14	90%	90%	Female & Male	No ramp up	N/A	N/A	N/A	50% (2023), 90% (2030)	N/A

MAC: Multi-age cohort; NA: Not applicable; Vaccination assumes nonavalent HPV vaccine, or other broad-spectrum HPV vaccine with protection against the seven oncogenic types

## Section 6. Detailed description of initial (pre-calibration) model assumptions for cancer treatment access, stage distribution, and survival.

Treatment for cervical cancer involves stage-appropriate multi-modality therapies with radiotherapy and chemotherapy, with surgery (partial or total hysterectomy) being an important option for early stage disease. Cervical cancer clinical staging was assumed to be based on the International Federation for Gynaecology and Obstetrics (FIGO) system. Stage distribution at diagnosis and survival rates by stage in treated and untreated women were based on a systematic review conducted by WHO, which obtained information from 43 countries, prioritising countries with population-based cancer registries as well as national documents or reports including cancer control plans, cross-referenced to data from IARC cancer registries. Stage distribution estimates were derived by IHME (Institute for Health Metrics and Evaluation) sub-regions and applied to the countries within those sub-regions. We used country-level information on treatment access rates (see below) along with the survival rates for treated and untreated women to derive initial estimates of country-level current *status quo* survival rates (see Table A6), which were then also summarised at a World Bank regional level (see Table 1, main manuscript).

Radiotherapy access data (estimated as machine density per 1000 cancer patients) was used as a surrogate for the derivation of initial (pre-calibration) model input for multi-modal treatment delivery. Treatment access rates were estimated based on the most recent (2018) data for radiotherapy access and availability of External Beam Radiation Therapy and personnel (radiation oncologists, medical physicists, and radiation therapy technologists) provided by the International Atomic Energy Agency's (IAEA) Directory of Radiotherapy Centres (DIRAC). Derived ranges of treatment access rates in each World Bank region (Table 1, main manuscript) encompassed the lowest and the highest treatment access rates of the countries in each region and represented the percent of the population that could potentially be serviced based on equipment and workforce available. If a country's estimated cancer treatment access rate was higher than the target scale-up in a given year, we assumed that the treatment access rate for the country was stable until treatment was scaled-up beyond the status quo value.

We used these data as an initial (pre-calibration) input to the models. Subsequently, each modelling group also applied a 'quality factor' to further adjust survival in the status-quo in order to fit to GLOBOCAN 2018 estimates for cervical cancer incidence by 5-year age-group, at a country level (see Appendix – Additional Results).

All screening intervention scenarios assumed that 90% of HPV positive women would receive adequate treatment for precancer. For successfully delivered precancer treatment, treatment success rates were assumed to be 100%. All screening intervention scenarios assumed 90% treatment delivery for screen-detected invasive cervical cancer. Models assumed scaled-up cancer treatment access for cancers that are symptomatically-detected in screening scenarios –specifically, for S2 and S3, 50% of clinically/symptomatically-detected cancers would receive treatment by 2023 and 90% would receive treatment by 2030.

Methods differed slightly for the Harvard model, which assumed 50% access by 2023 and 90% access by 2030 to high-quality cancer treatment for all screened- and clinically/symptomatically-detected cancers for scenarios involving screening, regardless of screening coverage rates, potentially underestimating the survival of screen-detected cancers during the first years while screening coverage scaled-up.

The increased survival associated with successful treatment scale-up was assumed to be equivalent across countries once the target treatment access of 90% was attained, except for two countries which had >90% treatment access in their status quo, in which case they maintained their higher status quo survival at all times (Table A7). At the modelling group level, a decision was made whether to adjust within-stage survival for mode of detection (e.g. in *Policy1-Cervix* the relative survival for screen-detected cervical cancer compared to symptomatically-detected cervical cancer is assumed to be 1.15 for localised disease and 1.17 for regional/distant disease).<sup>54-56</sup> For further information, refer to the schematics summarising treatment modelling for the comparator (S0) and Scenario 3 (S3) (Figure A5).

**Table A6. Assumed initial status quo country-specific stage distributions, survival rates, and treatment access rates**

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Cambodia	East Asia & Pacific	Lower middle income	KHM	Southeast Asia	0.22	0.39	0.27	0.12	0.639 (0.113)	0.497 (0.1)	0.129 (0.076)	0.017 (0.012)	0.130
Indonesia	East Asia & Pacific	Lower middle income	IDN	Southeast Asia	0.22	0.39	0.27	0.12	0.638 (0.11)	0.495 (0.097)	0.127 (0.073)	0.016 (0.011)	0.126
Korea Dem. Rep.	East Asia & Pacific	Low income	PRK	East Asia	0.46	0.31	0.18	0.05	0.616 (0.047)	0.469 (0.042)	0.083 (0.031)	0.007 (0.005)	0.054
Lao PDR	East Asia & Pacific	Lower middle income	LAO	Southeast Asia	0.22	0.39	0.27	0.12	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Mongolia	East Asia & Pacific	Lower middle income	MNG	Central Asia	0.23	0.27	0.34	0.16	0.707 (0.311)	0.579 (0.275)	0.268 (0.207)	0.047 (0.032)	0.358
Myanmar	East Asia & Pacific	Lower middle income	MMR	Southeast Asia	0.22	0.39	0.27	0.12	0.682 (0.238)	0.548 (0.21)	0.217 (0.158)	0.036 (0.025)	0.273
Papua New Guinea	East Asia & Pacific	Lower middle income	PNG	Oceania	0.12	0.56	0.28	0.04	0.625 (0.073)	0.48 (0.065)	0.101 (0.049)	0.011 (0.008)	0.084
Philippines	East Asia & Pacific	Lower middle income	PHL	Southeast Asia	0.22	0.39	0.27	0.12	0.683 (0.241)	0.55 (0.213)	0.219 (0.16)	0.036 (0.025)	0.277
Solomon Islands	East Asia & Pacific	Lower middle income	SLB	Oceania	0.12	0.56	0.28	0.04	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Timor-Leste	East Asia & Pacific	Lower middle income	TLS	Southeast Asia	0.22	0.39	0.27	0.12	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Vanuatu	East Asia & Pacific	Lower middle income	VUT	Oceania	0.12	0.56	0.28	0.04	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Viet Nam	East Asia & Pacific	Lower middle income	VNM	Southeast Asia	0.22	0.39	0.27	0.12	0.667 (0.195)	0.531 (0.173)	0.187 (0.13)	0.029 (0.02)	0.225
Georgia	Europe & Central Asia	Lower middle income	GEO	Central Asia	0.23	0.27	0.34	0.16	0.9 (0.87)	0.81 (0.77)	0.66 (0.58)	0.13 (0.09)	1.000
Kyrgyz Republic	Europe & Central Asia	Lower middle income	KGZ	Central Asia	0.23	0.27	0.34	0.16	0.692 (0.266)	0.56 (0.235)	0.236 (0.177)	0.04 (0.027)	0.306
Moldova	Europe & Central Asia	Lower middle income	MDA	Eastern Europe	0.39	0.15	0.26	0.2	0.659 (0.171)	0.521 (0.151)	0.17 (0.114)	0.026 (0.018)	0.196
Tajikistan	Europe & Central Asia	Low income	TJK	Central Asia	0.23	0.27	0.34	0.16	0.654 (0.156)	0.515 (0.138)	0.16 (0.104)	0.023 (0.016)	0.180
Ukraine	Europe & Central Asia	Lower middle income	UKR	Eastern Europe	0.39	0.15	0.26	0.2	0.78 (0.523)	0.666 (0.462)	0.416 (0.348)	0.078 (0.054)	0.601
Uzbekistan	Europe & Central Asia	Lower middle income	UZB	Central Asia	0.23	0.27	0.34	0.16	0.683 (0.241)	0.55 (0.213)	0.219 (0.16)	0.036 (0.025)	0.277

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Bolivia	Latin America & Caribbean	Lower middle income	BOL	Andean Latin America	0.22	0.21	0.54	0.03	0.741 (0.408)	0.619 (0.361)	0.336 (0.272)	0.061 (0.042)	0.469
El Salvador	Latin America & Caribbean	Lower middle income	SLV	Central Latin America	0.27	0.2	0.46	0.07	0.832 (0.674)	0.729 (0.597)	0.523 (0.449)	0.101 (0.07)	0.775
Haiti	Latin America & Caribbean	Low income	HTI	Caribbean	0.12	0.56	0.28	0.04	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Honduras	Latin America & Caribbean	Lower middle income	HND	Central Latin America	0.27	0.2	0.46	0.07	0.811 (0.613)	0.703 (0.542)	0.479 (0.408)	0.092 (0.063)	0.704
Nicaragua	Latin America & Caribbean	Lower middle income	NIC	Central Latin America	0.27	0.2	0.46	0.07	0.675 (0.219)	0.54 (0.194)	0.203 (0.146)	0.033 (0.023)	0.251
Djibouti	Middle East & North Africa	Lower middle income	DJI	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Egypt	Middle East & North Africa	Lower middle income	EGY	North Africa and Middle East	0.13	0.43	0.31	0.13	0.87 (0.783)	0.774 (0.693)	0.599 (0.522)	0.117 (0.081)	0.900
Morocco	Middle East & North Africa	Lower middle income	MAR	North Africa and Middle East	0.13	0.43	0.31	0.13	0.81 (0.61)	0.702 (0.54)	0.478 (0.407)	0.091 (0.063)	0.701
Palestine	Middle East & North Africa	Lower middle income	PSE	North Africa and Middle East	0.13	0.43	0.31	0.13	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Syrian Arab Republic	Middle East & North Africa	Low income	SYR	North Africa and Middle East	0.13	0.43	0.31	0.13	0.691 (0.263)	0.559 (0.233)	0.234 (0.175)	0.039 (0.027)	0.302
Tunisia	Middle East & North Africa	Lower middle income	TUN	North Africa and Middle East	0.13	0.43	0.31	0.13	0.9 (0.87)	0.81 (0.77)	0.66 (0.58)	0.13 (0.09)	1.000

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Yemen	Middle East & North Africa	Low income	YEM	North Africa and Middle East	0.13	0.43	0.31	0.13	0.646 (0.132)	0.505 (0.117)	0.143 (0.088)	0.02 (0.014)	0.152
Afghanistan	South Asia	Low income	AFG	North Africa and Middle East	0.11	0.87	0.31	0.13	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Bangladesh	South Asia	Lower middle income	BGD	South Asia	0.13	0.36	0.4	0.11	0.658 (0.167)	0.519 (0.148)	0.167 (0.112)	0.025 (0.017)	0.192
Bhutan	South Asia	Lower middle income	BTN	South Asia	0.13	0.36	0.4	0.11	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
India	South Asia	Lower middle income	IND	South Asia	0.13	0.36	0.4	0.11	0.757 (0.456)	0.639 (0.403)	0.369 (0.304)	0.068 (0.047)	0.524
Nepal	South Asia	Low income	NPL	South Asia	0.13	0.36	0.4	0.11	0.68 (0.233)	0.546 (0.206)	0.213 (0.155)	0.035 (0.024)	0.267
Pakistan	South Asia	Lower middle income	PAK	South Asia	0.13	0.36	0.4	0.11	0.7 (0.29)	0.57 (0.257)	0.253 (0.193)	0.043 (0.03)	0.333
Sri Lanka	South Asia	Lower middle income	LKA	Southeast Asia	0.22	0.39	0.27	0.12	0.766 (0.481)	0.649 (0.425)	0.387 (0.32)	0.072 (0.05)	0.552
Angola	Sub-Saharan Africa	Lower middle income	AGO	Central Sub-Saharan Africa	0.02	0.21	0.68	0.09	0.656 (0.164)	0.518 (0.145)	0.165 (0.109)	0.024 (0.017)	0.188
Benin	Sub-Saharan Africa	Low income	BEN	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Burkina Faso	Sub-Saharan Africa	Low income	BFA	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Burundi	Sub-Saharan Africa	Low income	BDI	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Cabo Verde	Sub-Saharan Africa	Lower middle income	CPV	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Cameroon	Sub-Saharan Africa	Lower middle income	CMR	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.619 (0.055)	0.473 (0.049)	0.089 (0.037)	0.008 (0.006)	0.063

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Central African Republic	Sub-Saharan Africa	Low income	CAF	Central Sub-Saharan Africa	0.016	0.21	0.68	0.09	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Chad	Sub-Saharan Africa	Low income	TCD	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Comoros	Sub-Saharan Africa	Low income	COM	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Congo	Sub-Saharan Africa	Lower middle income	COG	Central Sub-Saharan Africa	0.016	0.21	0.68	0.09	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Congo Dem. Rep.	Sub-Saharan Africa	Low income	COD	Central Sub-Saharan Africa	0.016	0.21	0.68	0.09	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Cote d'Ivoire	Sub-Saharan Africa	Lower middle income	CIV	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Eritrea	Sub-Saharan Africa	Low income	ERI	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
eSwatini (formerly Swaziland)	Sub-Saharan Africa	Lower middle income	SWZ	Southern Sub-Saharan Africa	0.02	0.38	0.48	0.12	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Ethiopia	Sub-Saharan Africa	Low income	ETH	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.609 (0.026)	0.461 (0.023)	0.068 (0.017)	0.004 (0.003)	0.030
Ghana	Sub-Saharan Africa	Lower middle income	GHA	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.639 (0.114)	0.497 (0.101)	0.13 (0.076)	0.017 (0.012)	0.131
Guinea	Sub-Saharan Africa	Low income	GIN	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Guinea-Bissau	Sub-Saharan Africa	Low income	GNB	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Kenya	Sub-Saharan Africa	Lower middle income	KEN	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.656 (0.164)	0.518 (0.145)	0.165 (0.109)	0.024 (0.017)	0.188
Lesotho	Sub-Saharan Africa	Lower middle income	LSO	Southern Sub-Saharan Africa	0.02	0.38	0.48	0.12	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Liberia	Sub-Saharan Africa	Low income	LBR	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Madagascar	Sub-Saharan Africa	Low income	MDG	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.633 (0.096)	0.49 (0.085)	0.118 (0.064)	0.014 (0.01)	0.111
Malawi	Sub-Saharan Africa	Low income	MWI	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Mali	Sub-Saharan Africa	Low income	MLI	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.623 (0.066)	0.477 (0.059)	0.097 (0.044)	0.01 (0.007)	0.076
Mauritania	Sub-Saharan Africa	Lower middle income	MRT	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.71 (0.318)	0.582 (0.282)	0.273 (0.212)	0.048 (0.033)	0.366
Mozambique	Sub-Saharan Africa	Low income	MOZ	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Niger	Sub-Saharan Africa	Low income	NER	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Nigeria	Sub-Saharan Africa	Lower middle income	NGA	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.605 (0.015)	0.456 (0.013)	0.061 (0.01)	0.002 (0.002)	0.017

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Rwanda	Sub-Saharan Africa	Low income	RWA	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Sao Tome and Principe	Sub-Saharan Africa	Lower middle income	STP	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Senegal	Sub-Saharan Africa	Low income	SEN	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Sierra Leone	Sub-Saharan Africa	Low income	SLE	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Somalia	Sub-Saharan Africa	Low income	SOM	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
South Sudan	Sub-Saharan Africa	Low income	SSD	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Sudan	Sub-Saharan Africa	Lower middle income	SDN	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.682 (0.237)	0.548 (0.209)	0.216 (0.158)	0.035 (0.024)	0.272
Tanzania	Sub-Saharan Africa	Low income	TZA	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.629 (0.083)	0.484 (0.073)	0.108 (0.055)	0.012 (0.009)	0.095
The Gambia	Sub-Saharan Africa	Low income	GMB	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Togo	Sub-Saharan Africa	Low income	TGO	Western Sub-Saharan Africa	0.09	0.4	0.45	0.06	0.6 (0)	0.45 (0)	0.05 (0)	0 (0)	0.000
Uganda	Sub-Saharan Africa	Low income	UGA	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.609 (0.027)	0.461 (0.024)	0.069 (0.018)	0.004 (0.003)	0.031

Country	World Bank Region	Income group	ISO Alpha-3 Code	IHME GHDx Region#	Stage distribution for 2020*				5-year (10-year) survival rate for 2020				Treatment access proportion in 2020**
					Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B	
Zambia	Sub-Saharan Africa	Lower middle income	ZMB	Eastern Sub-Saharan Africa	0.09	0.36	0.47	0.08	0.675 (0.217)	0.54 (0.192)	0.202 (0.144)	0.032 (0.022)	0.249
Zimbabwe	Sub-Saharan Africa	Low income	ZWE	Southern Sub-Saharan Africa	0.02	0.38	0.48	0.12	0.686 (0.249)	0.553 (0.22)	0.225 (0.166)	0.037 (0.026)	0.286

#IHME GHDx regions: Institute for Health Metrics and Evaluation for Global Health Data Exchange

\* Results are according to FIGO staging for carcinoma of cervix (2009 version) and TNM 7th Ed. Stage distribution at diagnosis was based on a systematic review conducted by WHO, which obtained information from 43 countries, prioritising countries with population-based cancer registries. Results were derived by IHME (Institute for Health Metrics and Evaluation) sub-regions and applied to the countries within those sub-regions.

\*\* Treatment access rates were estimated based on radiotherapy access, calculated on the basis of the most recent availability of external beam radiation therapy and personnel (radiation oncologists, medical physicists, and radiation therapy technologists) which were provided by the Directory of Radiotherapy Centres (DIRAC). Treatment access represents the proportion of the population that could potentially be serviced based on equipment and workforce. If a country's estimated cancer treatment access rate is higher than the target scale-up in a given year, we assumed that the treatment access rate for the country was stable until treatment was scaled-up beyond the status quo value.

We used these data as an initial (pre-calibration) input to the models; however, each modelling group also applied a 'quality factor' to further adjust survival in the status quo in order to fit to GLOBOCAN 2018 estimates for cervical cancer mortality by 5-year age-group (see main manuscript).

**Table A7. Assumed stage-specific survival after scale-up of treatment access to 90%, all countries**

	5-year survival*				10-year survival*			
	Stage 1	Stage 2	Stage 3-4A	Stage 4B	Stage 1	Stage 2	Stage 3-4A	Stage 4B
Survival for all-78 LMICs with 90% treatment scale-up	0.8700	0.7740	0.5990	0.1170	0.7830	0.6930	0.5220	0.0810

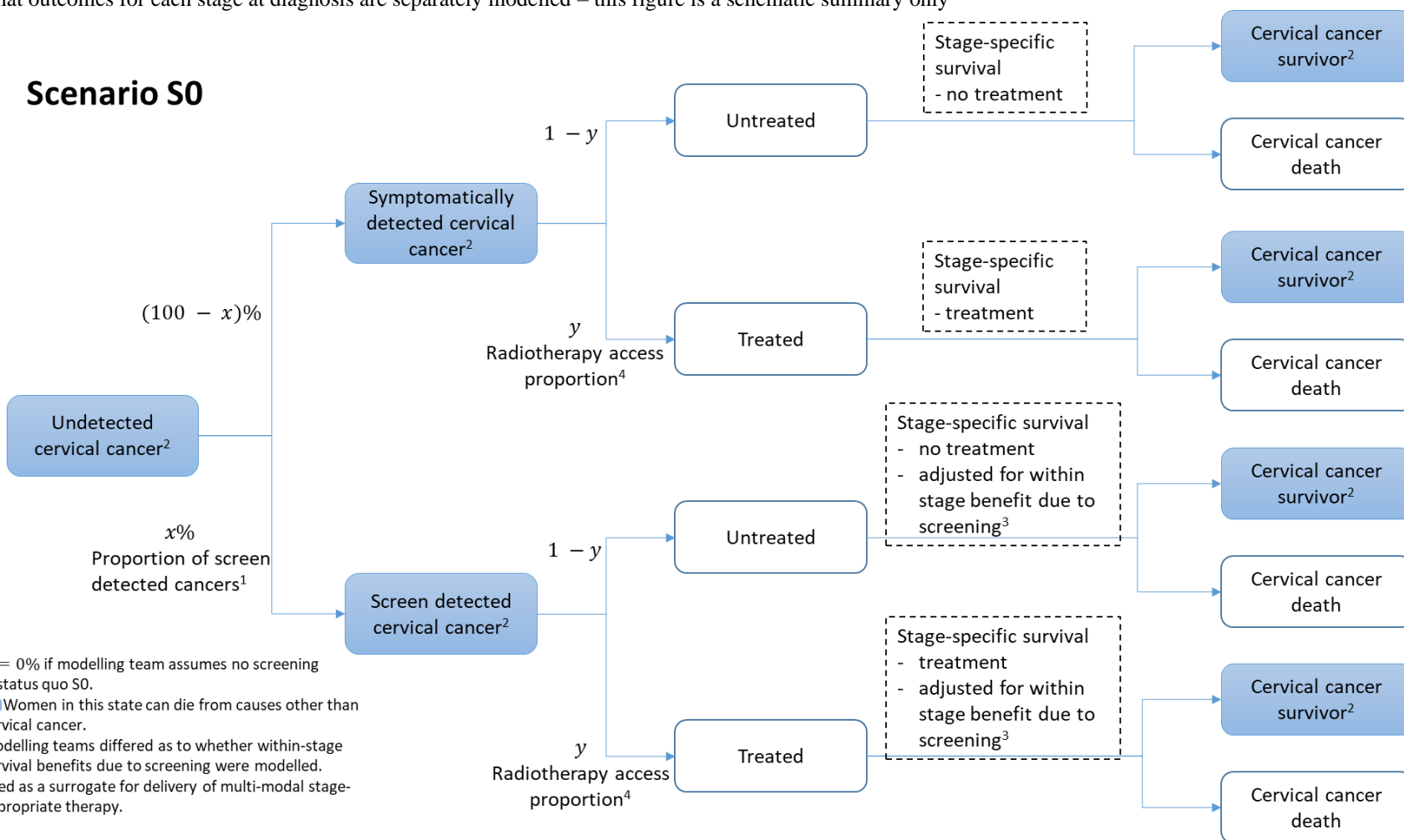
\* Results are according to FIGO staging for carcinoma of cervix (2009 version) and TNM 7th Ed.

Countries with more than 90% treatment access in the status quo (of which there are only two) were assumed to retain their status quo survival rates after treatment scale-up.

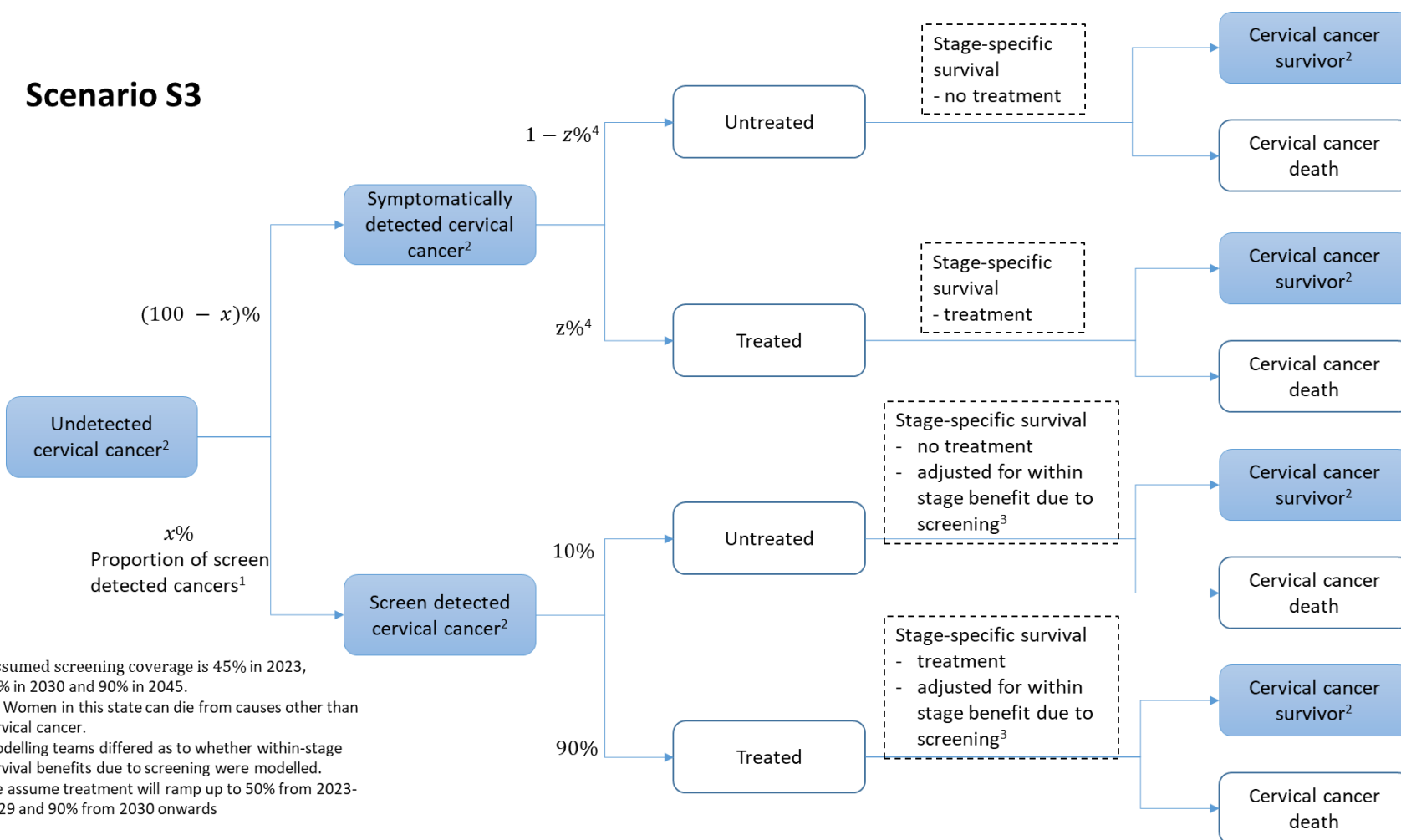
**Figure A5. Schematic showing treatment modelling approach for S0 and S3**

Note that outcomes for each stage at diagnosis are separately modelled – this figure is a schematic summary only

## Scenario S0



## Scenario S3



### Notes:

1. Assumed screening coverage is 45% in 2023, 70% in 2030 and 90% in 2045.
2.   Women in this state can die from causes other than cervical cancer.
3. Modelling teams differed as to whether within-stage survival benefits due to screening were modelled.
4. We assume treatment will ramp up to 50% from 2023-2029 and 90% from 2030 onwards

## Section 7. HPV-FRAME reporting standard

The checklist below includes core reporting standard, reporting standard for model of HPV vaccination, model of integrated HPV vaccination and cervical screening, and model for LMICs, according to Canfell et al, 2019.<sup>57</sup>

**Table A9. HPV-FRAME reporting standard checklist**

a) Inputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F-only, M-only or both)?	Comments
<b>Core reporting standard</b>				
Target population for intervention	Y	Y	Y	Vaccination: females aged 9 years; single year of catch-up ages 10-14 years or 10-25 years. Vaccination of boys considered in exploratory analyses. Screening: at age 35 years +/- age 45 years Cancer treatment: all ages. (Methods section of manuscript and pages 57-62 of Appendix. Countries included in the analysis are reported in Appendix pages 44-45.)
Sexual behaviour	Y	Y (for dynamic models)	Y	The transmission model/ sexual behaviour parameters were used to inform the expected reduction in the HPV incidence rates due to HPV vaccination. (Pages 50-56 of Appendix)
Cohort examined for evaluation/ time horizon	Y	N	F-only	101 year time horizon (2020-2120) reported for cervical cancer outcomes. Age-specific results reported for 2020, 2070, 2120. (Methods section of manuscript)
Quality of life assumptions	Not applicable	Not applicable	Not applicable	This paper focuses on the impacts on health outcomes only
Calibration	Y	Y	F-only	All models reproduce GLOBOCAN 2018 incidence at a country level. The models were then calibrated to final mortality outcomes to country- and age-specific rates from GLOBOCAN 2018 by incorporating a 'quality factor' into the final estimated country- and stage-specific survival assumptions. (methods in main manuscript; Technical Appendix) Results of the model calibration were comparable for the three models and demonstrated good fit with GLOBOCAN 2018. (Pages 3-7 of Appendix)
Validation (where possible)	Y	Y (implicitly)	F-only	The individual CCEMC models previously have been used to various HPV vaccination and cervical screening strategies for many countries, including high- resource countries, low-resource settings and globally. (Pages 50-56 of Appendix)
Costs	Not applicable	Not applicable	Not applicable	This paper focuses on the impacts on health outcomes only
<b>Reporting standard for HPV vaccination in adolescent individuals</b>				
Vaccine uptake	Y	Y	Y	The uptake and target ages for different scenarios are reported. Core scenarios assumed 90% of girls aged 9 years would be vaccinated with a broad-spectrum HPV vaccine, plus single year of catch-up ages 10-14 years. (Methods section of manuscript and pages 57-62 of Appendix.)
Vaccine efficacy	Y (implicitly)	Y (implicitly)	Y (implicitly)	100% vaccine efficacy was assumed, independent of age and sex
Vaccine cross-protection	Y (implicitly)	Y (implicitly)	Y (implicitly)	We assume that the vaccine provides 100% efficacy for HPV16, 18, 31, 33, 45, 51 and 58.
Reporting standard for model of cervical screening				

a) Inputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F- only, M-only or both)?	Comments
Routine screening behaviour (routine and follow-up and test of cure)	Y	Y	F-only	Screening coverage for once-lifetime screening at age 35 years or twice-lifetime screening at age 35 and 45 is described in (Methods section of manuscript and pages 57-62 of Appendix.)
Screening test (s) and colposcopy accuracies	Y	Y (implicitly)	F-only	Sensitivity of HPV test was assumed 90% for CIN2 and 94% for CIN3+ across three models, and assumed to be independent of age. We did not model assumed a specific test to confirm cancer diagnosis. However, we assume 90% of women detected as HPV infection and diagnosed with a lesion will be treated. We also assume that 90% of women with detected cancer are treated. (Methods section of the manuscript).
Abnormal test management (primary and triage)	Y	Y (implicitly)	F-only	Assumed to be independent of age. We assumed 90% of women who detected HPV positivity and pre-cancer would be treated. Similarly, we also assumed 90% of women with HPV positivity and cancer would be treated. (Methods section of the manuscript).
Diagnostic follow-up of abnormal tests	N	N	F-only	Diagnostic confirmation was not explicitly modelled; we assumed 90% of women with HPV positivity and cancer would be treated.
Management by disease grade (confirmed disease)	N	N	F-only	Given the aim of this study, we did not report in this level of detail in this paper.
Sources of information for screening structure and parameterization		Y	F-only	The screening pathway follows WHO recommendations for LMICs. It was simplified for the global modelling exercise. Model parameters were based on literature review, assumptions, and data from WHO and IARC.
Reporting standards for integrated models of HPV vaccination and cervical screening				
HPV type incidence, clearance and progression rates	Y (implicitly)	Y (implicitly)	Y (implicitly)	Type-specific HPV incidence, clearance, and progression were modelled separately for HPV16,18, other oncogenic nonavalent-included types (31/33/45/52/58) and other oncogenic nonavalent-non-included types. (Detailed model descriptions and references to other sources on model parameters described in Appendix pages 50-56)
Herd effect	Y (implicitly)	Y (implicitly)	Y (implicitly)	Herd effect of HPV vaccination were assumed to capture by dynamic transmission component of all three models. (Appendix pages 50-56)
Association between vaccination and screening uptake	Y	Y	F-only (N/A for males)	Vaccine and screening uptake were assumed to be independent of one another.
<b>Reporting standard for models of HPV prevention in LMICs</b>				
HIV prevalence rates, if endemic in country	N	N	N	We did not explicitly take into account HIV prevalence in this study. (Discussion section of manuscript).
Description of any opportunistic or pilot/demonstration screening project ongoing	N	N	N	As this study models the impact of fully scaling-up HPV vaccination and cervical screening strategies in 78 LMICs, this is not relevant.

b) Outputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F- only, M-only or both)?	Report as calibration or validation target? (Y/N)
<b>Core reporting standard</b>				
Cancer incidence, mortality, life years, QALYs/DALYs (as appropriate)	Y	Y	F-only	Age-standardised and age-specific incidence and mortality rates were reported. We also reported number of deaths averted as the impacts of HPV vaccination and screening strategies for women aged 0-99 years and 30-69 years. (Results section in manuscript and Appendix pages 8-26). Not reported for LYs, QALYs, DALYs as this paper focuses on the impacts on cancer incidence and mortality only
HPV prevalence, pre-intervention	N	N	N	This level of detail is not reported. This paper focuses on the impact on cancer mortality and results were also not sensitive to herd immunity effects. HPV prevalence is thus not a driver of our conclusions.
CIN2 detected	N	N	N	This level of detail is not reported. This paper focuses on the impact on cancer mortality. Impact of interventions on CIN2 was thus not a focus of the paper.
Sensitivity analysis on key inputs	Y (implicitly)	Y (implicitly)	F-only	This was a comparative analysis using three models with different structural and parameterisation assumptions. As such a form of sensitivity analysis is built into the reported ranges of results between models. Also we did a number of additional exploratory/explanatory scenarios to understand the sensitivity of the model results to underlying aspects of the impact modelling and specific sensitivity analysis around population assumptions. (Appendix pages 33-43)
Incremental cost-effectiveness ratios and costs saved		N	N	This paper focuses on the impacts on cancer incidence and mortality only
Reporting standard for HPV vaccination in adolescent individuals				
Absolute reductions in HPV infections, cervical, and other HPV-related cancers and/or warts post vaccination	N	N	F-only	This paper only focuses on the reduction of cervical cancer mortality (and incidence) post vaccination.
Absolute reduction in CIN2+ post vaccination	N	N	F-only	This paper only focuses on the reduction of cervical cancer mortality (and incidence) post vaccination, so this level of detail is not reported.
Absolute reduction in invasive cancer post-vaccination		N	F-only	Outputs considered the absolute reduction in age-standardised rates of cervical cancer mortality in HPV vaccination scenarios. (Results section of manuscript and Appendix pages 8-32).

QALYs: quality-adjusted life-years

DALYs: disability-adjusted life-years

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